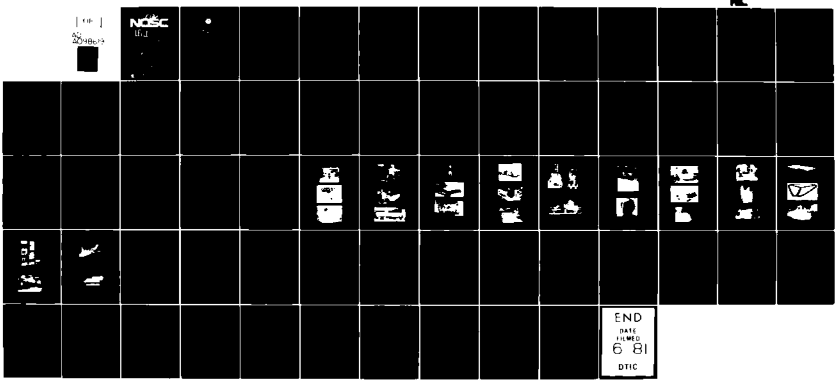
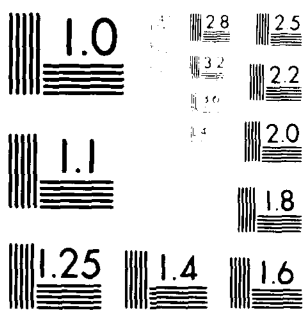
AD-A098 619   NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA   F/G 13/10.1
OCEAN TECHNOLOGY - A DIGEST. REVISION 1.(U)
FEB 81
UNCLASSIFIED   NOSC/TD-149-REV-1   NL





MICROCOPY RESOLUTION TEST CHART

NOSC

NOSC TD 149
REV 1

LEVEL III

A058370

Technical Document 149
Revision 1

OCEAN TECHNOLOGY — A DIGEST

February 1981

Approved for public release; distribution unlimited.

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

SL GUILLE, CAPT, USN
Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

Sponsored by a variety of agencies, the technical effort of the Naval Ocean Systems Center is wide in scope. Since the Center is directed by the Naval Material Command, its primary tasks are based on requirements defined by the Chief of Naval Operations and the Naval Material Command.

Of the work described in this report, the primary tasks were sponsored by offices within the Sea, Facilities, Air, and Electronic Systems Commands of the Naval Material Command. Additional tasks were sponsored by the Office of Naval Research, the Defense Advanced Research Projects Agency, and some active Fleet commands.

The tasks reported fall into all the areas of the Center's technological scope, in which it:

Conducts research, development, test, and evaluation of systems and techniques that provide the Navy with safe and reliable means for the acomplishment of engineering projects in the sea—employing men, manned submersibles, and unmanned, remotely controlled machine systems.

Develops deep-submergence technology in general support of present and future Navy operational requirements.

Applies principles of ocean engineering to the design of systems for the Navy's combat and noncombat missions.

Supports the Navy's Fleet operations by satisfying their quick-response needs in hardware for undersea operations.

Released by
HR TALKINGTON, Head
Ocean Technology Department
and
JD HIGHTOWER, Head
Environmental Sciences Department

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1 REPORT NUMBER: NOSC Technical Document 149 (TD 149) Revision 1

2 GOVT ACCESSION NO.: AD-A098 619

3 RECIPIENT'S CATALOG NUMBER

4 TITLE (and Subtitle): OCEAN TECHNOLOGY – A Digest

5 TYPE OF REPORT & PERIOD COVERED

6 PERFORMING ORG. REPORT NUMBER

7 AUTHOR(s):

Ocean Technology and Environmental Sciences Departments
Naval Ocean Systems Center
San Diego, California 92152

8 CONTRACT OR GRANT NUMBER(s)

9 PERFORMING ORGANIZATION NAME AND ADDRESS:
Naval Ocean Systems Center
San Diego, California 92152

10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11 CONTROLLING OFFICE NAME AND ADDRESS

12 REPORT DATE: February 1981

13 NUMBER OF PAGES: 60

14 MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15 SECURITY CLASS. (of this report): Unclassified

15a DECLASSIFICATION DOWNGRADING SCHEDULE

16 DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18 SUPPLEMENTARY NOTES

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Acoustic imaging
Marine engineering – Oceanography
Material testing
Ocean bottom – Searching
Ocean surveillance
Optical imaging
Technology – Oceans
Vehicles, Maintenance
Vehicles – Underwater – Deep submergence

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document presents summaries of projects completed, underway, or in planning within the Naval Ocean Systems Center as of February 1981. It is intended to demonstrate the scope of NOSC's ocean engineering effort and provide specific examples of the Center's capabilities in this area. The projects described exemplify research, development, testing, and evaluation in the following areas: remotely controlled underwater vehicles, manned submersibles with panoramic visibility, launch and recovery of submersibles, pressure-resistant hulls and materials, diver equipment, salvage systems, undersea imaging, untethered deep-ocean buoys, stationary floating ocean platforms, and self-propelled ocean platforms. Additional projects include study of the effects of ocean submersion on radio-

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19.

Stable ocean platforms
Self-propelled ocean platforms
Sonar detection
Pressure-resistant electronic components
Inflatable structures
Air-film technology
Systems management
Underwater cables
Computerized simulation
Immersion
Radio isotope batteries
Systems engineering

20. (Cont)

isotope power units, application of system integration techniques to the development and deployment of undersea sensor arrays, and provision of engineering support for Fleet units and research and development facilities.

CONTENTS

INTRODUCTION . . . page 5

UNMANNED VEHICLES . . . 6

- **current projects**

  Cable-controlled Underwater Recovery Vehicle (CURV II) . . . 6
  Cable-controlled Underwater Recovery Vehicle (CURV III) . . . 7
  Submersible Cable-Actuated Teleoperator (SCAT) . . . 7
  NAVFAC SNOOPY . . . 8
  Mine Neutralization System . . . 9
  Free-Swimming Vehicle . . . 9
  Solid Rocket Booster Dewatering System . . . 10
  USAF Recovery System . . . 11

- **past achievements**

  SNOOPY . . . 11
  ELECTRIC SNOOPY . . . 11

TECHNOLOGICAL DEVELOPMENT . . . 12

- **current projects**

  Transparent Materials . . . 12
  Windows and Housings for IR Imaging Systems . . . 13
  High-Strength-to-Weight-Ratio Materials . . . 14
  Lightweight Undersea Cables . . . 14
  Fiber Optics in Undersea Systems . . . 15
  Pressure-Tolerant Electronics . . . 16
  Deployable Undersea Sensors . . . 16
  Advanced Unmanned Search System (AUSS) . . . 18
  Precise Integrated Navigation System (PINS) . . . 19
  Optical Imaging . . . 19
  Acoustic Data Link . . . 20
  Display System Variables . . . 21
  Deep-Ocean Work and Recovery . . . 21
  Tethered Float Breakwater . . . 22
  Information Systems and Technologies Program (ISAT) . . . 22
  Optical Oceanographic Data Link for Expendable Sensors (OODLES) . . . 23

CONTENTS (continued)

Advanced Teleoperator Technology . . . 24
Fixed-Volume Lift Bag and Lift Module . . . 25
USMC Waterproof Equipment and Weapons Bags . . . 25

- **past achievements**

Real-Time Optical Mapping System (ROMS) . . . 26
Acoustic Imaging . . . 26
Underwater Lights . . . 27
Head-Coupled Television . . . 27
Suction Cup Recovery Device . . . 39
Water Level Detector . . . 39
Hydrodynamic Winch (Hydro-Winch) . . . 39
SONODIVER . . . 40
Remote Unmanned Work System (RUWS) . . . 40
Pontoon Implacement Vehicle / Work Systems Package (PIV/WSP). . . 41

TECHNOLOGICAL APPLICATIONS . . . 42

- **current projects**

DUMAND—A Large, Deep-Ocean Neutrino Detector . . . 42
Acoustic Data Collection . . . 43
Cable Technology Handbook . . . 44
Ocean Engineering Handling System . . . 44
Directional Sensor . . . 44

- **past achievements**

Synthetic Fiber Rope Program . . . 45
Coupling for Synthetic Rope . . . 45
Inflatable Array Framework . . . 45
Fixed Endfire Surveillance Array—Barrier Line . . . 46
Air-Film Technology . . . 46
Inter-Seamount Acoustic Range (ISAR) . . . 47

CONTENTS (Continued)

PLATFORMS . . . 47

- **current projects**

SWATH Ship . . . 48
SSP KAIMALINO . . . 48
Benthic Untethered Multipurpose Platform (BUMP) . . . 49

- **past achievements**

Floating Stable Platform . . . 50

OBSERVATION PLATFORMS WITH PANORAMIC VISIBILITY . . . 50

- **current project**

SEA-SEE . . . 50

- **past achievements**

Oceanographic Research Tower/Acrylic Elevator . . . 51
Hull Inspection Platform (HIP) . . . 51

SUBMERSIBLES WITH PANORAMIC VISIBILITY . . . 52

- **past achievements**

Naval Experimental Manned Observatory (NEMO) . . . 52
DEEP VIEW . . . 52
MAKAKAI (Eye of the Sea) . . . 53

DEEP SUBMERSIBLES FOR RESCUE, SEARCH, AND SALVAGE . . . 53

- **current projects**

TURTLE and SEA CLIFF . . . 54
Submarine Rescue Unit (SRU) . . . 54
DSRV Optics Program . . . 55
Simulated Distressed Submarine . . . 55

CONTENTS (Continued)

- **past achievements**

  Deep-Submergence Rescue Vehicle . . . 56
  TRIESTE . . . 56

LAUNCH AND RETRIEVAL OF SUBMERSIBLES . . . 57

- **past achievements**

  Launch and Recovery Platform (LARP) . . . 57
  Semisubmerged Stable Support Platform Concept . . . 57
  Helicopter Launch and Recovery . . . 58

DIVING TECHNOLOGY . . . 58

- **past achievements**

  ELK RIVER (IX-501) . . . 59
  Submersible Training Platform . . . 59
  Diver's Navigation System . . . 60
  Passive Image-Intensifier Goggles . . . 60

INTRODUCTION

This digest of ocean engineering projects at the Naval Ocean systems Center was prepared as an aid for visitors to the Center. Its objective is to provide those facts and figures that would otherwise be jotted down in a notebook during a briefing on each of the projects. In order to make this document most useful, it has purposely been kept small in size, with short concise statements. Requests for further information on any particular subject will be welcomed.

Selected examples of past projects are also included to give an expression of the breadth of experience at NOSC and provide data that might be applied directly to the solution of some particular problem.

The projects described exemplify research, development, and test and evaluation in many areas to support the basic objectives in ocean engineering at the Center, that is, to provide safe and reliable means for accomplishment of engineering projects within the sea in support of combatant as well as non-combatant missions of the US Navy.

UNMANNED VEHICLES

Although manned submersibles can, properly equipped, perform any conceivable mission in the ocean, in many cases they do so only at great cost and some risk to their crews. Thus, a program was initiated at NOSC for the development of tethered, unmanned, remotely controlled work systems. These systems have proven to be very reliable ocean engineering tools to both the oceanographic investigator and the Navy. The continuing research at NOSC assures that each generation of such systems is significantly improved in operational capabilities, while operational costs and shipboard support requirements are substantially decreased. Work has recently commenced on a new generation of vehicles which show great promise for future operations: unmanned free-swimming vehicles which incorporate robotic techniques.

CURRENT PROJECTS

CABLE-CONTROLLED UNDERWATER RECOVERY VEHICLE (CURV II)

The improved CURV II is an unmanned tethered submersible capable of operating to 6000 feet. It is the successor to CURV I, which recovered the H-bomb off the coast of Spain in 1966. In configuration, CURV II is typical of most unmanned vehicles; it has an open rectangular framework to support the sensors and tools, two horizontal propulsion motors to drive and steer the vehicle, one vertical motor for close vertical control, and buoyancy of approximately 25 pounds. The vehicle is 6.5 feet high, 6.5 feet wide, and 15 feet long, weighs 3000 pounds in air, and operates at submerged speeds to 4 knots. The sensors include an Applied Research Lab active/passive sonar, acoustic altimeter and depthometer, compass, two Hydroproducts television cameras with lights, and an EG&G 35-mm still camera with strobe. One major feature of all surface-powered vehicles is that their bottom time is restricted only by the ability of the surface support craft to remain on station.

The CURV II system consists of the vehicle, control cable, and control console. Although it often operates from the YFNX 30 surface support ship, the system can be air transported to operate from any surface ship of opportunity. It is primarily used for recovery of practice torpedoes from NOSC ranges.

CABLE-CONTROLLED UNDERWATER RECOVERY VEHICLE (CURV III)

CURV III, a greater-depth version of CURV II, is capable of operating at depths to 7000 feet at a submerged speed of 4 knots. It has been modified for emergency operations to 10 000 feet. The CURV III system consists of the vehicle, control cable, and control console. Although it often operates from the YFNX 30, the system is designed so that all major operational components can be disassembled, air transported to a work site, and installed on any surface craft that has adequate deck space. The vehicle normally carries a hydraulically operated claw for attaching and recovering items, such as ordnance, from the ocean floor. For special tasks, the claw is removed and replaced by a variety of grasping, cutting, or working tools. The vehicle also contains the necessary equipment for searching, locating, and documenting the lost item. Control of the vehicle and monitoring of operations are performed in the control van. The vehicle is 6.5 feet high, 6.5 feet wide, 15 feet long, and weighs 4500 pounds in air. Its instrument suite includes a Straza 500 active/passive sonar with transponder interrogation capability, acoustic altimeter and depthometer, compass, two Hydroproducts television cameras with lights, and an EG&G 35-mm still camera with strobe.

CURV III is a versatile underwater vehicle that can be readily modified to accommodate a wide variety of underwater tasks. It has demonstrated its search and recovery capabilities off the west coast as well as in the Atlantic Ocean, most notably during the 1973 rescue of the PISCES III submersible off Ireland.

SUBMERSIBLE CABLE-ACTUATED TELEOPERATOR (SCAT)

As originally configured, SCAT was built to act as a test-bed demonstration vehicle primarily for the purpose of evaluating head-coupled television. It is currently being reconfigured as a light-duty inspection/work vehicle capable of operating to 2000-foot depths.

SCAT can be considered an intermediate vehicle between SNOOPY and CURV. Tethered by a multiconductor cable, SCAT carries a black-and-white television camera with one 250-watt quartz iodide lamp and a 50-frame 35-mm camera and strobe mounted on a pan-and-tilt assembly. Sensor capability also includes a sonar system depth sensor and compass. A specially designed electrohydraulic system consisting of an electric motor, fixed-displacement pump, relief valve, and reservoir drives hydraulic motors connected to ducted thrusters and provides maneuverability in both horizontal and vertical directions. In addition, five 2-way servo valves are being added to the system to allow for various work functions, which may include a rudimentary manipulator or special-purpose tools. While seated at the control con-

sole, the SCAT operator views on a conventional TV monitor the image relayed by the submersible's television camera. The orientation of the camera is controlled by a hand-operated pan-and-tilt control. The entire SCAT system (vehicle, control console, power distribution unit, main cable, and power generator) is designed for transportation by commercial aircraft and can be accommodated by their handling systems and cargo spaces. SCAT has a dry weight of 975 pounds and is 39 inches wide, 71 inches long, and 52 inches high.

NAVFAC SNOOPY

NAVFAC SNOOPY is a small, remotely controlled vehicle system which was designed and fabricated at NOSC at the request of the Naval Facilities Engineering Command for ocean construction work. Its primary uses are optical survey of proposed undersea construction or implantment sites, surveillance and documentation of diver operations, and general undersea inspection and documentation.

The vehicle's design depth is 1500 feet. It employs four hydraulically powered thrusters for horizontal and vertical excursions. The three horizontal thrusters are controlled by a three-axis proportional joystick for integrated forward, reverse, turning, and lateral vehicle motion. The vertical thruster control employs automatic depth- and altitude-holding circuitry with manual override. A television camera is used for real-time viewing, and a Super-8 movie camera provides color photographic documentation. Vehicle instrumentation data, which consist of heading, depth, and altitude, are relayed to the surface by a time-division multiplex system. All instrument data are digitally displayed at the control console, and an additional "sense indication" display is provided for vehicle heading. The vehicle power, control signals, video signal, and instrument data are multiplexed onto a single coaxial tether, which is of small diameter for reduced hydrodynamic drag and ease of handling. This vehicle weighs approximately 500 pounds in air and is 48 inches long, 36 inches wide, and 28 inches high.

The NAVFAC SNOOPY system was recently modified to provide improvements to the multiplexer, hydraulic power unit, and thruster subsystems. A small scanning sonar subsystem was added to permit target localization and limited area search. Surface and subsurface components of the sonar suite are connected by a small-diameter cable attached, at intervals, to the main system tether cable.

Potential applications for this vehicle and others of its type also include implantment of objects on the sea floor (marking pingers, etc.) and recovery of both large and small objects. The primary advantages that the small, remotely controlled vehicles offer are safety, unlimited endurance, low initial and operating costs, portability, and direct availability of remote information to control personnel.

MINE NEUTRALIZATION SYSTEM

NOSC has developed and tested the Advanced Development Model of the Mine Neutralization System (MNS), consisting of an unmanned, remotely controlled, tethered undersea vehicle which is deployed from a minesweeper. The vehicle is used to classify and neutralize sea mines previously detected by sonar. Once a mine has been detected by sonar, the vehicle is launched via the vehicle's specialized launch and recovery system. The vehicle contains its own high-resolution scanning sonar and undersea TV system for relocation and classification of the target mine. Once classification has been effected, the mine is neutralized and the vehicle is returned to the ship.

An umbilical handling system automatically stores, pays out, and hauls in the vehicle's umbilical cable as the operational situation requires. Control of the vehicle is accomplished from a specially designed control console located in the ship's Combat Information Center. A multiplex system supplies power and control to the vehicle while transmitting sensor information from the vehicle to the control console.

NOSC is presently NAVSEA's Technical Agent for the development of the Engineering Development Model of the MNS. In addition to monitoring the prime contractor's development effort and directing the TECHEVAL, NOSC is developing the cable cutters carried by the vehicle.

FREE-SWIMMING VEHICLE

The free-swimming vehicle is a robotic test-bed submersible developed to demonstrate improved vehicle system technology. This submersible, which is 9 feet long, about 20 inches high, and 20 inches wide, has a modular construction which allows expansion to accommodate additional payloads and new sensor systems as the technology for those systems advances to the point at which fabrication and testing become feasible. The vehicle is designed to follow a set of predetermined program tracks, such as a parallel-path search or a figure-8 demonstration run. In this mode of operation, the vehicle is programmed via a computer console and an umbilical cable, which is disconnected after the initial preprogramming phase. The vehicle is then allowed to follow this course until its mission is complete. If an emergency arises, there are automatic procedures that allow the vehicle to turn on an emergency beacon. This action shuts off all thrusters, and the vehicle is recovered at the surface. After initial tests with this mode of operation, other methods of vehicle command control and communication will be demonstrated. In particular, an acoustic control link and an acoustic slow-scan television link are planned. The end result will be a system which is not limited by cable

drag and cable-handling problems and one which should perform rudimentary tasks without direct operator control.

SOLID ROCKET BOOSTER DEWATERING SYSTEM

NOSC has been tasked by the National Aeronautics and Space Administration (NASA) to design, develop, and test a solid rocket booster (SRB) dewatering system. The prototype dewatering system consists of a tethered, unmanned vehicle (nozzle plug); a control console; and handling, deployment, storage, and support subsystems. The dewatering system will be used to recover the expended SRB cases of the space shuttle system after they have been jettisoned and are floating in the sea.

The nozzle plug (NP) vehicle docks and locks itself into the nozzle of the partially flooded booster case, which is floating in a spar mode with the nozzle 100–125 feet below the surface. Water is forced out of the SRB with compressed air from the surface support ship. When sufficiently dewatered, the SRB goes into a "log" mode, and a sealing bag on the NP vehicle is inflated to seal the nozzle. A hose is then deployed and the remaining water is forced out through the nozzle plug.

Prime power for the system is provided by a 440-volt, 400-Hz, 3-phase generator aboard the support ship. This power is supplied to the vehicle through a 600-foot umbilical. The umbilical also contains a 1½-inch air line, through which air to dewater the SRB is supplied at 150 psi.

All vehicle subsystems are hydraulically operated. Hydraulic power is provided by two 15-horsepower motor pump units in the NP vehicle. These provide up to 16 gal/min at 3000 psi.

Vehicle thrust is provided by six 5½-horsepower thrusters, four horizontal and two vertical. The horizontal thrusters are controlled individually so the vehicle can move in any horizontal direction without requiring a yaw maneuver. This feature allows the operator to follow the SRB motions during the docking maneuver.

The vehicle is equipped with a TV camera and lights and a compass for navigation. Horizontal control can be tied into the compass at the option of the operator for automatic horizontal hold.

The vehicle is 14 feet high; the main body is 30 inches in diameter. Total vehicle weight in air is 3400 pounds.

USAF RECOVERY SYSTEM

A cost-effective recovery system for the space shuttle's solid rocket boosters (SRB) and associated hardware has been established to provide significant cost savings for the shuttle program. On each flight, two SRBs are separated from the orbiter after expending their fuel. They are decelerated by three main parachutes. The SRB frustum and drogue separate from the booster upon deployment of the main parachutes. All of these components are to be recovered from the sea.

A single recovery platform is being developed with all related recovery equipment, winches, dewatering sets, and contingency items. This platform will house the recovery crew and be capable of on-station operations for a minimum of 7 days. The platform will be self-propelled and will tow back to port one SRB, with an on-call leased tug towing the second SRB. This retrieval system, complete and ready to go with a trained crew, will be delivered to the Air Force Space Division in early 1984.

PAST ACHIEVEMENTS

SNOOPY

SNOOPY is the smallest in a series of lightweight, portable, unmanned undersea vehicle systems. It is capable of carrying a TV camera with a 250-watt mercury vapor light source into the sea environment. As such, it is capable of replacing a diver in many tasks for which observation or surveillance is required. The system uses hydraulic fluid pressure of 1500 psi and delivers ⅕ horsepower to each of two thrusters for underwater propulsion. SNOOPY has two unique features: all propulsion power is sent from the surface by hydraulic lines, and an automatic depth-keeping capability is provided by a variable-buoyancy chamber and a depth-feedback system. A small, electrically powered grabber is mounted on the forward end for implanting or retrieving lightweight objects. The vehicle weighs 50 pounds and operates to depths of 100 feet.

ELECTRIC SNOOPY

ELECTRIC SNOOPY, the successor to SNOOPY, differs from its predecessor principally in its propulsion scheme and its depth capability of 1500 feet. This vehicle uses three ¼-horsepower, oil-filled, pressure-balanced electric motors for thrust in the horizontal and vertical directions. This approach allows the use of a small-diameter tether cable. Power (ac), along with multiplexer control signals, is sent down the cable and converted to variable-dc motor-drive voltage through motor controllers at the vehicle. Twin pressure

hulls house all vehicle electronics in addition to a television camera and a Super-8 camera, thus providing a streamlined and responsive vehicle. The Super-8 camera provides intervals of action footage or a large number of individual-frame pictures. The vehicle is 24 inches wide, 40 inches long, and 18 inches high. It weighs 155 pounds in air and is made neutrally buoyant by a rectangular slab of syntactic foam with a density of 36 pounds per cubic foot.

TECHNOLOGICAL DEVELOPMENT

Traditionally the Navy has taken the lead in advancing technology applicable to underwater requirements. New methods are developed and materials are adapted for underwater use to meet the specific needs of naval programs. Some aspects of technology finding application in underwater service are materials, acoustic and visual sensing equipment, and operational systems.

CURRENT PROJECTS

TRANSPARENT MATERIALS

Underwater panoramic visibility is important to the Navy in operations involving exploration, research, salvage, and ocean engineering. Panoramic visibility improves operating safety, convenience, and efficiency in the undersea environment. Research is providing the transparent materials that will permit improved viewing for observation and maneuvering.

Transparent materials with the required properties are incorporated into pressure-resistant structural designs. The transparent structural assemblies are evaluated under simulated deep-ocean conditions. Small viewports for abyssal depths and large viewports with panoramic visibility for continental depths have been fabricated and evaluated.

The current state of this technology permits inclusion in manned systems of acrylic viewports and transparent pressure hulls up to 6 feet in diameter that can function at depths down to 3000 feet. A design Safety Standard has been developed that provides the pertinent criteria for design and procurement of acrylic viewports by government activities. In addition, the American Bureau of Shipping and the US

Coast Guard have adopted this Safety Standard for the commercial offshore diving industry.

Since the requirements of underwater photo-optical systems cannot be satisfied by deformable acrylic plastic, viewports for this application have been developed utilizing glass or transparent ceramic materials. Spherical-sector glass windows with an 8-inch diameter have been successfully tested to 20 000 psi pressure.

WINDOWS AND HOUSINGS FOR IR IMAGING SYSTEMS

Surveillance of the ocean surface and secure naval communications require infrared energy transmitters and receivers for shipboard use. To operate effectively, this equipment must be furnished with windows that are transparent to infrared energy and capable of withstanding the marine environment for prolonged periods without significant deterioration of the optical surfaces.

After several years of experimental and analytical studies, NOSC has developed a capability to design germanium windows rugged enough to resist the effects of wave slap and/or immersion at ocean depths. Fabrication is accomplished by contractors. To date, windows in the shape of plane discs, plane rectangles, spherical sectors, and hyperhemispheres have been designed, fabricated, and experimentally evaluated in mountings that minimize stress due to edge effect. These evaluations usually include wave slap, hydrostatic pressure, dynamic overpressure, point impact, thermal shock, biofouling, and seawater corrosion tests. For arctic applications, tests of heating techniques, meant to keep the windows free of ice, are also included.

Although germanium is the primary material for IR windows, other materials, such as ZnSe, ZnS, Al_2O_3, and Ge and chalcogenide glass, have been considered. These materials show great promise for multispectral imaging systems, which operate in both the visible and IR energy spectra. Thus far, only exploratory investigations have been conducted with these materials, with the exception of Ge glass, which has been studied extensively. Ge glass has been found to be ideally suited for marine applications since it is totally unaffected by seawater. This glass can be used for massive windows or for coating germanium windows. In this combination, the germanium provides structural strength, while the Ge glass coating protects the optical surface. The current state of this technology allows fabrication of large Ge glass windows of up to 10 inches in diameter.

HIGH-STRENGTH-TO-WEIGHT-RATIO MATERIALS

High-strength, lightweight steel alloys, aluminum, and titanium are all fairly well-developed materials that are used in undersea systems. However, the real advances in retaining high strength while greatly reducing weight appear to be in the future development of plastics, glass, and synthetic fibers. NOSC has an active program in development of transparent materials, such as acrylic, glass, and certain ceramics, that have very high compressive strength and resistance. Work is progressing in the development of reliable, repeatable manufacturing technology and safety certification criteria. A current synthetic aramid fiber, KEVLAR-49, shows great promise as a reinforcing component for replacing glass in GRP (glass-reinforced plastic) fiber glass with a 33-percent reduction in volume and a 50-percent reduction in weight (for equal strength) for pressure housings. This high tensile strength (200 000 psi) and modulus of elasticity (12 000 000 psi) of KEVLAR-49 make it an ideal material to replace steel as the strcngth member in composite cables for undersea use. KEVLAR provides a weight-saving factor over steel of about 6 to 1 and is nearly neutrally buoyant in seawater. These materials have direct application to undersea systems as pressure hulls, hydrodynamic fairings, structural members, windows, and cabling.

LIGHTWEIGHT UNDERSEA CABLES

A recently completed program has developed a series of deep-sea electromechanical cables characterized by high strength and low weight in water. The strength member for these cables is KEVLAR-49, an organic fiber from DuPont which combines usable tensile strength comparable to that of steel with an in-water weight about one-twentieth that of steel. The component cable, when used as a deep-sea tether, has 5 to 10 times the strength/self-weight capability of conventional steel-armored cables.

Two types of cables have been developed. The first is a 23 000-foot coaxial cable contrahelically armored with KEVLAR-49 strength members in much the same way that conventional cables are armored with steel wires. It has been operated as the primary support link between a surface ship and the Remote Unmanned Work System (RUWS), described elsewhere in this booklet.

The second cable demonstrates that KEVLAR-49 technology can be used to build cables that combine high strength, multiple conductors, and neutral buoyancy at deep-ocean pressures. The demonstration unit has 20 conductors, a breaking strength of 13 000 pounds, a (jacketed) diameter of 1 inch, and a specific gravity between 1.0 and 1.015.

One of the early objections to the use of KEVLAR-49 in cables has been its high cost—about $50/pound when processed into a form analogous to cylindrical steel wires. More recent work has shown that the material can be formed into cables in its natural form—a multifilament yarn—at a material cost of $8.50/pound. (This corresponds to a cost of about $1.50/pound for cabling steels yielding the same strength.) Little or no penalty in strength is paid, although some reduction in flexure lifetime has been experienced.

FIBER OPTICS IN UNDERSEA SYSTEMS

The emergence of optical fiber as a replacement for metallic conductors in communications cables has improved the performance of many types of undersea systems and led to the development of new systems made possible by the unique properties of fiber optics. Only fiber optic cables can convey information signals in a manner which is essentially independent of cable diameter. Fiber optic cables offer improved bandwidth and superior resistance to electromagnetic interference (EMI).

NOSC is conducting experiments in the application of fiber optic technology to such tethered undersea systems as the Mine Neutralization System (MNS) to significantly increase overall performance levels. Composite cables containing optical fibers, power conductors, and strength members have been designed, constructed, and tested which satisfy mechanical and electrical constraints imposed by this application. These cables exhibit vastly improved information-transfer characteristics over conventional designs while completely eliminating EMI pickup by the cable. NOSC studies have shown that fiber optic cable realizations can outperform conventional designs in many respects and that such cables are readily manufacturable by means of current industrial practice.

NOSC is applying fiber optics technology to the REGAL Torpedo communications tether cable. The use of a small-diameter (0.035 inch) cable allows long lengths of communications tether to be stored in the form of a small, precision-wound spool aboard the torpedo for high-speed deployment during the mission of the weapon. Order-of-magnitude savings in in-water weight result compared with metallic torpedo wires, covertness is maintained because a seawater return circuit is not required, and the characteristics of the optical communications channel do not vary as a function of payout (as in the case of a coiled wire). Wavelength duplex couplers have been developed which permit bidirectional communications to be supported by a single optical fiber, and a NOSC-designed demountable pressure penetrator serves to convey the optical signals from the high-pressure environment of the cable to the interior of the torpedo, where they are decoded by the optoelectronic interface.

Efforts are underway to marry the deployable tether cable technology developed for REGAL with the wide-bandwidth data-handling interface developed for MNS. The resulting system will be installed aboard the NOSC Free-Swimming Vehicle, transforming it into a "supervisory-controlled" vehicle. This evolution represents a new concept in undersea systems: an undersea vehicle exhibiting the advantages associated with tethered systems, but without the disadvantages resulting from cable drag and cable handling systems.

Work is ongoing to develop "oceanized" fiber optic components for use in undersea systems. Pressure-tolerant injection lasers and light-emiting diodes have been developed for use in communications and sensor applications. Pressure penetrators have been fabricated for use in systems not employing pressure-tolerant optoelectronics.

PRESSURE-TOLERANT ELECTRONICS

To increase reliability and failure tolerance in the design of undersea systems, the size and number of pressure-resistant containers must be kept to a minimum. One way to do this is to place the electronic components in an oil-filled, lightweight case which is equalized to the ambient sea pressure. This technique eliminates implodable volumes and high-pressure seals and connectors and provides increased heat dissipation. Because of potential cost savings, it is desirable to use off-the-shelf products if they can be certified to withstand the pressure. As a result, the suitability of available electrical components for performance under hydrostatic pressure is being investigated, along with measures to assure reliability.

Many types of components have been tested and shown to operate to pressures of 15 000 psi. These components range from simple bipolar and field effect transistors to state-of-the-art charge-coupled-device (CCD) imagers. All tests were performed with the components in a liquid-pressure environment. Liquids used include silicone oil, hydrocarbon hydraulic oils, and fluorinert fluids.

Many systems have been fabricated at NOSC and elsewhere using the technology of pressure-tolerant electronics. Among them are a pressure-tolerant TV camera (tested to 20 000 feet), an acoustic imaging system, a sonar suite for the USS DOLPHIN (AGSS 555), a beamformer for endfire acoustic line arrays, and a diver-worn decompression computer.

DEPLOYABLE UNDERSEA SENSORS

Ocean technology is being applied to deployable undersea sensors and arrays for undersea surveillance and ASW applications.

Critical technologies are being explored for the sensor systems and concepts described below.

FLOATING RANDOM ARRAYS

The technology of forming a coherent array from a concentrated field of freely drifting sensors is being demonstrated. Array element location is accomplished by active sources within the array. The ability to form beams is being demonstrated at sea by measuring the array signal gain and comparing it to the predicted 20 log N, where N is the number of array elements. Signal processing, display, and operator interaction architectures are being developed.

BOTTOM-MOUNTED RANDOM ARRAYS

Deployment systems are being developed for distributing a random field of sensors above the ocean bottom. These arrays would be processed in the same manner as the floating random array. They will obtain the same performance advantages while having much longer life.

The deployment mechanism being investigated consists of glide bodies deployed from a suspended master buoy. Upon command, these winged anchors glide away from the master buoy, laying a data link connected to the master buoy and releasing buoyant acoustic sensors upon impacting the bottom. The acoustic data are collected and conditioned at the master buoy for transmission to the surface or to shore. The resultant array would be a dynamic, randomly distributed, coherently processed sensor. Larger arrays may be obtained by connecting several master buoys to a common data link.

WATER-INFLATED BALLOON ARRAYS

Feasibility studies are being conducted on the performance and construction of large, inflated spherical-shell arrays. These three-dimensional arrays would have unique beams to obtain high acoustic performance. Because of the cylindrical symmetry, physical orientation of the arrays is not required.

ARRAY SHAPE MEASUREMENT

Beamforming for towed, deployed, or suspended line arrays is often based upon the assumption that the array is straight and that relative element locations are thus known. NOSC is developing methods of measuring the shapes of connected arrays so that the straightness constraint may be relaxed. This results in improved array gains, improved performance through intentional distortion to eliminate the port-starboard bearing ambiguity, and improved signal-to-

noise ratio resulting from the quieter condition of a slower towing speed.

Two methods of array shape measurement are being investigated. The self-cohering method uses signals from sources such as distant surface ships to measure the differential element-to-element arrival time. These measurements, coupled with the known element-to-element separation, are used as data for a least-squares fit algorithm to determine array shape. The second method uses heading sensor and tow velocity measurements as data for a hydrodynamic model of the array motion. By taking into account the drag parallel and perpendicular to the array tow direction, the array shape is predicted.

ADVANCED UNMANNED SEARCH SYSTEM (AUSS)

The Navy has a need to locate and classify man-made objects on the sea floor to depths of 20 000 feet. Such deep-ocean search is a complex process consisting of a large number of operations performed under widely different field conditions and in a highly variable environment. It requires the use of sophisticated systems to look for objects whose size and shape may be unknown.

The AUSS program is a systems approach to the development of the equipment required for deep-ocean operations. Its object is to provide the technology necessary for the acquisition of significantly improved search systems. The complexity of the search problem demands guidance of a quantitative nature to identify those areas of technology having the greatest potential for leading to enhanced search procedures.

This program has as its major goal the improvement of the Navy's deep-ocean search capability by an order of magnitude within the next decade. A major element in the program is the AUSS model. This is a large-scale search simulation computer model developed for systems and hardware tradeoff studies. The model assists in the selection of appropriate search hardware and predicts the performance of a final AUSS configuration. The model accepts a number of inputs to specify the search scenario and sensor platform type and then calculates the search figure of merit (mission time), search performance, and even details of a suggested sensor platform. The figure of merit is useful when comparing different platform types, search tactics, or other variables in search scenarios.

The second part of the AUSS program is subsystem development. With the AUSS model providing supporting analysis, specific subsystems influencing the reduction of search time are identified and targeted for technological improvement.

In the AUSS third program area, system development, various vehicle systems are utilized as test-beds to obtain component and subsystem integration performance data in the field. A significant component in this area is the development of a free-swimming, vehicle-based test-bed search system.

Completing the AUSS program is the acquisition data package. This is a coherent body of accumulated information which can aid project managers in the specification and acquisition of search systems to satisfy particular Fleet requirements.

PRECISE INTEGRATED NAVIGATION SYSTEM (PINS)

NOSC has completed the development of the Advanced Development Model of a Precise Integrated Navigation System (PINS) for use aboard Navy mine countermeasures (MCM) ships. PINS consists of various radio, acoustic, and inertial navigational aids, a computer, and various peripheral display devices. Inputs from the sensors are collected and compared by the computer in order to obtain a best estimate of the ship's present position. That position, the positions of any mines or other objects, and the positions of various other points of interest are listed, plotted on an X-Y plotter, and displayed on a cathode ray tube.

PINS not only allows the MCM ship to keep accurate track of the mines and mine-like objects it finds during the course of its mission, it also aids the ship in following a preset course, thereby permitting it to use its resources and time more efficiently. This is accomplished by providing the operators of the ship with displays that keep them informed of their present location and of their performance with respect to following a course assigned by the tactical officer in charge.

As it performs its navigational task, PINS will also act to coordinate and integrate the operations of the high-resolution sonar and the Mine Neutralization System that are also aboard the MCM ship.

NOSC is presently acting as Technical Agent to NAVSEA in the procurement of Engineering Development Models for TECH/OPEVAL.

OPTICAL IMAGING

For several years, NOSC has been involved in the development of advanced optical imaging systems in the hope of improving underwater viewing ranges, image resolution, and display systems. Several demonstration systems have been fabricated. Comparison testing was conducted to experimentally evaluate the performance of these systems. In particular, conventional underwater systems and systems

which use various backscatter-reduction techniques to improve underwater visibility were tested. Comparison data were obtained for all systems under similar test and water-property conditions. Resolution capabilities of the various sytems were measured as functions of viewing range, target contrast, and water clarity.

To predict the performance of future television systems, studies were conducted to determine optimum components which could be used for each system. Computer simulations were then used to obtain viewing-range capabilities of the hypothetical systems. The effects of various parameter changes, such as field of view, source–receiver separation, and receiver sensitivity, were also investigated. Once the detection and image-contrast criteria of a receiver have been established, operating ranges of a given system can be determined.

A handbook of advanced underwater optical imaging systems has been published which presents the results of these investigations and a means of theoretically evaluating various image systems. This has been extremely valuable to people in the Navy who are responsible for evaluating proposals and choosing an optimum design approach for large Navy procurements.

ACOUSTIC DATA LINK

NOSC investigation of underwater acoustic telemetry, such as slow-scan television, has led to the development of an advanced acoustic data link. This link shows promise of providing a real-time, cableless telemetry system capable of handling the flow of control and sensor data between surface vessels and underwater vehicles. To date, several tests have been conducted in which slow-scan television data and various test signals have been acoustically transmitted to the surface through the vertical water column from a depth of 3700 feet.

During the May 1980 test, pseudorandom digital data were also transmitted (for the first time) at a rate of 2400 bits per second (bps) over two independent channels. For each channel, the bit error rate of the data received at the surface was better than 1×10^{-4}.

The system is currently being modified to enable the transmission of data at 4800 bps over a single channel with an error rate of better than 1×10^{-5}. Tests will be performed to verify that this performance can be realized in water depths from 2000 to 20 000 feet, with the surface vessel horizontally offset from the submersible by an amount less than or equal to the submersible's depth.

DISPLAY SYSTEM VARIABLES

As a task for Office of Naval Research, basic research has been performed to improve the efficiency of remote vehicle operators. The major focus of this task is to conduct research on and identify the key variables affecting remote vehicle operator performance. The range of research includes studies of display system parameters and task demands encountered by the remote vehicle operator and the manipulator operator.

Three general manipulator tasks have been selected for detailed examination. An investigation has been made of the operator's visual task requirements, and the perceptual and motor demands for the performance of these tasks have been studied. An experimental laboratory technique has been developed to simulate the degraded underwater visibility conditions which occur as a result of the backscattering of light.

Recent studies have been conducted to assess manipulator operator performance under various levels of degraded visibility (clear, moderate, poor) using a conventional TV display in comparison with recently developed stereo displays. An analysis of the interaction of the perceptual, learning, and task factors which contribute to performance has been made. Findings indicate that manipulator performance under degraded visibility conditions fell off faster for conventional than for stereo viewing systems. Significant learning effects were found for both stereo and conventional systems across tasks and visibility conditions; however, unpracticed subjects performed better on certain tasks when using stereo-displayed information.

Currently studies are being conducted to assess the influence of head-motion parallax cues on manipulator operator performance under standardized task conditions. One goal of this line of research is to test the efficiency of movement-produced cues which result from the use of head-coupled TV viewing systems. The overall objective is to develop a general theoretical model from which a standard set of testing conditions may be derived to test the many practical and theoretical questions involved in the integration of teleoperator system components and which will enable a greater understanding of the perceptual and motor needs of the operator.

DEEP-OCEAN WORK AND RECOVERY

A multi-laboratory working group, led by NOSC, has been investigating technology for work and recovery in the deep ocean. Programs such as the Work Systems Package (WSP), the Remote Unmanned Work System (RUWS), and Extended Salvage Depth Capability (ESDC) have provided considerable baseline technology. Laboratory

and at-sea studies are being conducted in the areas of undersea work systems, recovery attachments, manipulators, limited-bandwidth viewing systems, microprocessor-controlled lift modules, gas generation systems, cable dynamics, and most other areas associated with tethered unmanned vehicle/work systems. The ultimate aim of these studies is the specification, fabrication, or documentation of representative equipment or systems that will form a technology base to allow the Navy to perform work and/or recovery operations to ocean depths of 20 000 feet.

TETHERED FLOAT BREAKWATER

The Tethered Float Breakwater (TFB) project is a combined effort of the Naval Ocean Systems Center, Naval Facilities Engineering Command, and US Army Corps of Engineers. The TFB was designed to develop a low-cost, portable breakwater that could be used wherever reduction of prevailing sea conditions is desired—in harbor and marina protection, amphibious assaults, offshore transfer operations, and drilling and dredging operations.

The TFB operates on the principle of energy extraction. Buoyant spheres or cylinders in equivalent volume are tethered below the surface. High buoyancy provides a restoring force to the float as the wave passes; the system acts as a damped oscillator with a natural frequency determined principally by the length of the tether and mass of the float. As a wave passes through the breakwater, the energy of the wave is dissipated in the motion of the floats by overcoming the fluid drag associated with their oscillatory motion. This reduction in energy decreases the height of the waves behind the float field.

A model TFB consisting of moored ballast sections and 12-inch-diameter floats has been fabricated and installed in San Diego Bay. A 2-year test and evaluation program has yielded a workable system with results applied to the development of a full-scale, bottom-resting model. The ocean hardware consists of ballast assemblies fabricated from steel rail and pipe, synthetic tethers with molded terminations, and floats made from foam-filled automobile tires. The test site is located off Imperial Beach, California, and is subjected to open-ocean waves throughout the year.

INFORMATION SYSTEMS AND TECHNOLOGIES PROGRAM (ISAT)

A critical part of every R&D project is the creation and handling of technical and managerial information. Data, specifications, reports, photographs, drawings, correspondence—all must be handled. The effectiveness and efficiency of the project often depend on the ability of

the team to handle the information smoothly. The ISAT program is aimed at developing tools to meet these needs.

Part of the ISAT work is technological—developing, applying, adapting new and old technologies and techniques for information handling in a Navy R&D environment. Accomplishments to date include:

- The Undersea Surveillance Library—an automated, secure library of R&D documents related to undersea surveillance.
- Computer-Generated Video Tapes—time-lapse video recording of advanced computer displays for subsequent instant replay.
- Microfiche Image Transmission System—a complete system design and study of the feasibility of transmitting Navy personnel records (and other documents) from microfiche over long distances by electronic means.
- Video Image Storage and Retrieval—a system using video technology to store and rapidly retrieve a large number of photographic images.
- Video Communication System—a system of many different information sources (TV cameras, computers, microfiche files, video players, document scanners, etc.) interconnected through a user-controlled switching system. Users have consoles in their offices, similar to terminals of a computer network. This enables them (and their entire organization) to provide, gain, and share access to information resources in a flexible, effective, and efficient manner.
- Mobile Sonar Technology Data Bank—a data bank of R&D literature related to sonar and underwater acoustics, available on a nationwide basis and indexed to meet the specialized needs of technological experts.

The ISAT program also deals with the individuals, groups, and organizations served by information systems. This work includes designing, developing or modifying, and implementing information systems to meet ocean engineering needs.

OPTICAL OCEANOGRAPHIC DATA LINK FOR EXPENDABLE SENSORS (OODLES)

The expendable bathythermograph (XBT) is a universal tool for physical oceanographers. An extremely simple device, the XBT consists of a weight, an attached coil of wire in a streamlined enclosure

with tail fins, and a temperature sensor. The unit is dropped over the side of a ship and quickly reaches terminal velocity, streaming out wire as it falls. A shipboard monitor records temperature as a function of time, but the data are reported as temperature versus depth because time at terminal velocity can be converted to sensor depth.

The recent development of more sophisticated expendable sensors (sound velocity and current velocity profilers) and the need for a more precise indication of depth has led to the development of OODLES, a digital fiber optic telemetry link. OODLES will facilitate the incorporation of several oceanographic sensors into a single expendable unit, each sensor monitored in real time at the surface vessel via an expendable fiber optic link. The fiber optic link lifts the constraints on the time-bandwidth product associated with wire telemetry.

OODLES will be designed to have sensor channels with an accuracy of 14 bits per channel. It will operate to a depth of 1300 metres and provide sensor data at depth increments of 0.1 metre. Maximum deployment vessel speed is 5.1 metres/second (about 10 knots).

ADVANCED TELEOPERATOR TECHNOLOGY

The Advanced Teleoperator Technology program is a technology development effort that began in FY 1980. The objectives of this program are to integrate and advance the technologies relevant to the development of advanced general teleoperator systems and demonstrate the feasibility and advantages of these advanced systems to perform a variety of important Navy and Marine Corps warfare and support missions.

The approach consists of three parts: (1) identification of deficient technology and technology integration areas, (2) technology development and integration, and (3) technology evaluation and demonstration. A "top-down" approach has been selected to identify the deficient technology areas and aid in directing program resources toward them. It is "top-down" in the sense that it is driven by high-payoff applications determined by analyzing mission scenarios and projected threats.

The program will emphasize the development and integration of the subsystems necessary to acquire and "display" direct and extended sensory information to an operator so that he may "feel" presence at the remote site. The program will initially direct the majority of the effort toward two major subsystems: (1) an integrated stereo vision and display combination that will emphasize providing the operator with the impression that he is at the remote location and (2) an anthropomorphic manipulator arm and controller incorporating sensory feedback, i.e., touch and force.

The investigations necessary to determine the requirements and specifications for both the integrated vision system and the manipulator are underway. The contract to initiate development of the vision system is being negotiated. The development strategy for the manipulator will be finalized in April 1981. Actual development is scheduled to begin before the end of the year.

FIXED-VOLUME LIFT BAG AND LIFT MODULE

NOSC has developed two sizes of fixed-volume lift bags for use in deep-ocean recovery and salvage operations: a 10 000-pound-capacity unit (150 cubic feet) and a 3200-pound-capacity unit (50 cubic feet). Both have been tested at diver depths and down to several hundred feet. Each has demonstrated the concept of constant-buoyancy ascents. Recently these bags were combined with a microprocessor-based system to create a controlled-ascent demonstration lift module. This device uses lift bags in conjunction with a self-contained air source and pumping system to provide automatic and/or diver- (or submersible-) controlled motion. The microprocessor can be programmed to produce a specific ascent profile, including variable ascent and descent velocities and automatic hovering.

USMC WATERPROOF EQUIPMENT AND WEAPONS BAGS

Marine Corps reconnaissance personnel require waterproof equipment and weapons bags to enable them to execute amphibious missions via small inflatable boat (IBS) or submarine. The primary function of these bags is to protect equipment, packs, clothing, ammunition, and weapons from any of the sea, surf, and weather conditions that might be encountered. Three types of bags are needed, a weapons bag and two general-purpose equipment bags, one for operations at or near the ocean surface and generally used for transporting equipment by IBS and the other, a subsurface model, used during operations that require diving. The aim of the NOSC program is to develop each type of bag. The program consists of the design, fabrication, testing, and certification of prototypes. Final emphasis of the program is to provide adequate documentation so that the Marine Corps can procure production models to meet basis-of-issue requirements for reconnaissance units.

Design of the surface bag has been completed and a prototype is being fabricated. It is cylindrical (19 inches in diameter by 24 inches long) and constructed of abrasion-resistant vinyl. It is equipped with waterproof zippers, has a burst strength of 5 to 7 psi, and can accommodate a filled USMC "Alice" pack. The subsurface bag is in the final design stage. It will be of similar size and construction and fitted with a buoyancy-compensation device to be used in diving operations down to 200 feet. A prototype of the weapons bag is being fabricated also.

Constructed of the same material, it is 6 inches in diameter by 39 inches long and designed to contain the M-16 rifle. It will attach to either equipment bag by means of straps and Velcro strips. All three bags can be inflated orally to provide buoyancy.

PAST ACHIEVEMENTS

REAL-TIME OPTICAL MAPPING SYSTEMS (ROMS)

The NOSC Real-Time Optical Mapping System (ROMS) successfully completed its first in-ocean test at the San Clemente Island test range during September 1977. ROMS is an advanced optical viewing system capable of reducing the detrimental effects of backscatter through the use of the volume-scanning principle. The system consists of a flying-spot scanner in an underwater transparent acrylic housing approximately 9 feet long and 2 feet in diameter. The light source is an argon ion laser, which is mechanically scanned to illuminate a 120-degree fan beam. The resulting system produces real-time optical pictures of the ocean bottom from a 120-foot height with a 400-foot swath width. The system can be towed at any speed from 0 to 5 knots to provide the vertical sweep.

Images made with the ROMS (at the NOSC transducer facility) of divers swimming through the scanned laser beam have demonstrated the resolution quality obtainable with this configuration. The divers were clearly recognizable, even down to the fully sleeved suit of one diver and the short-sleeved suit of the other. In the original data, such small details as the pressure gauges were clearly distinguished.

ACOUSTIC IMAGING

Inadequate viewing ability is one of the most critical problems faced by operators of manned and unmanned underwater vehicles. Acoustic imaging technology is one major approach to improved underwater visibility.

Ocean waters absorb and scatter both light and sound. However, these effects limit optical imaging ranges more severely than they limit acoustic imaging ranges. Acoustic imaging is therefore useful over longer distances than optical imaging and is useful in murky water, where TV and other optical systems are limited. The resolution of acoustic imaging, however, is poorer than that of optical imaging. This implies that acoustic imaging is most useful when optical imaging is limited by turbidity or distance from the object.

One program goal is to develop acoustic imaging systems to extend the viewing ranges beyond those of optical viewing systems,

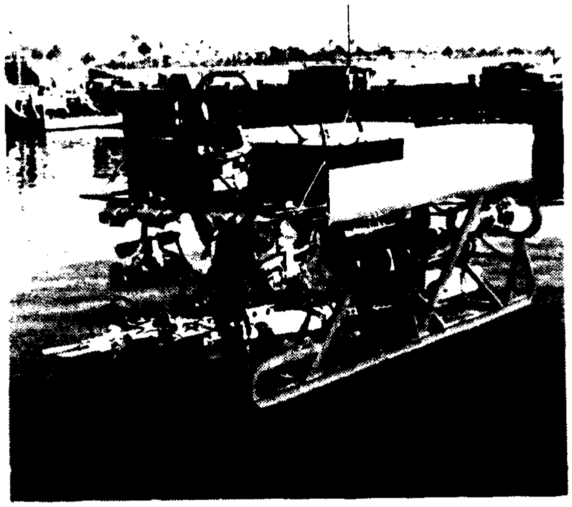
particularly in turbid waters. The program concentrates on developing hardware, generating analyses, and gathering empirical data in an effort to improve the performance and reduce the cost and complexity of acoustic imaging systems. In pursuit of these goals, the program developed an Acoustic Imaging System (AIS) for real-time acoustic viewing from a deep submersible. The AIS has accomplished real-time acoustic imaging of a 5-inch sphere to ranges of 1000 feet. At shorter ranges, it has achieved 0.3-degree resolution of images of spheres and other objects over its 22-degree field of view. Also, the program has engendered an awareness of the several technologies involved in acoustic imaging. This will be reflected in future systems developed to meet Navy requirements.

UNDERWATER LIGHTS

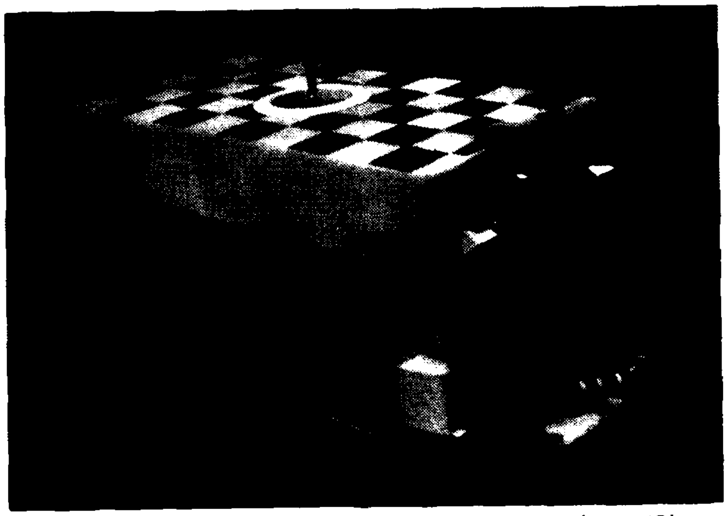
Natural illumination is inadequate for underwater television cameras at depths below 100 metres. Since existing underwater light systems do not provide optimum lighting, a program to provide more suitable light sources was undertaken at NOSC. Two sources have been developed, one a short-arc gas-discharge light containing mercury, xenon, and thallium iodide, and another containing xenon,cadmium, and zinc. Initial test results have indicated that the lights perform satisfactorily. Spectral emission of the first light was concentrated primarily in the green portion of the visible spectrum, while that of the second was concentrated in the blue portion. The first light will function best in coastal waters, the second in the deep sea. Compared with the standard thallium iodide–mercury light, the electrical-to-optical conversion efficiency for the new lights is high, and the start-up and restart times are much shorter.

HEAD-COUPLED TELEVISION

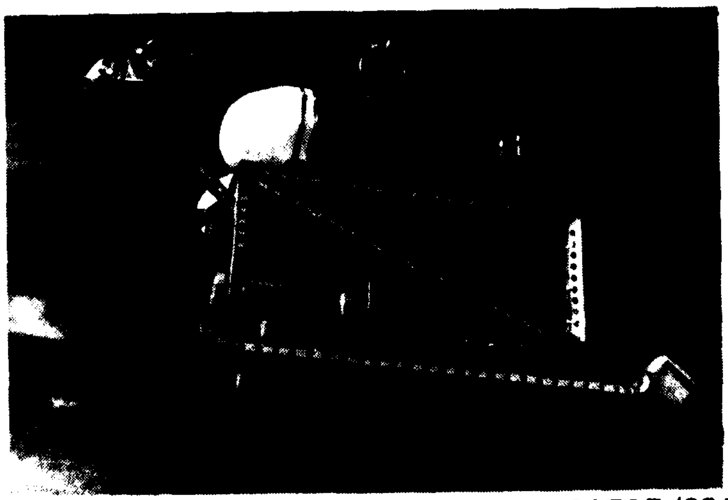
The Head-Coupled Television (HCTV) and Sonar system was built by NOSC to evaluate and demonstrate the degree of "operator presence" which could be obtained with such a system. The operator, wearing specialized equipment, simultaneously views a TV monitor presentation and hears an audio signal containing information from the sonar return signal from the direction in which the camera is pointed. The remote pan-and-tilt is positioned by an electrohydraulic position-feedback system. This system causes the camera to be pointed in the direction in which the operator is pointing his head. The operator's perceptions and responses are then what they would be if he were physically present at the underwater camera and his hands free for other tasks. HCTV systems have been incorporated into the SCAT and RUWS unmanned vehicles.



CURV III.

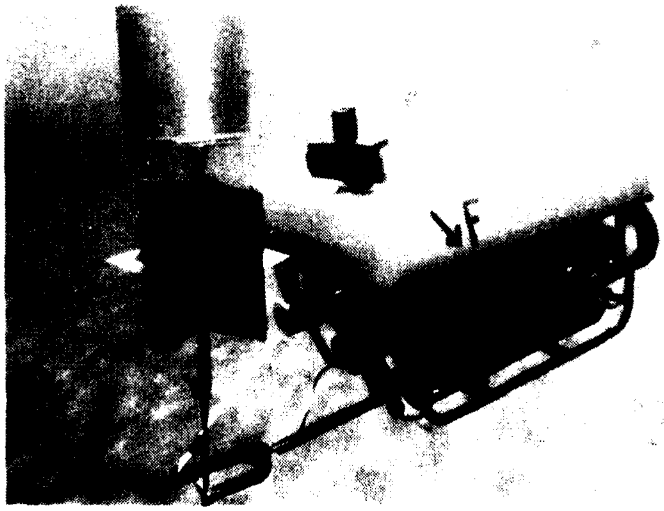


REMOTE UNMANNED WORK SYSTEM (RUWS).

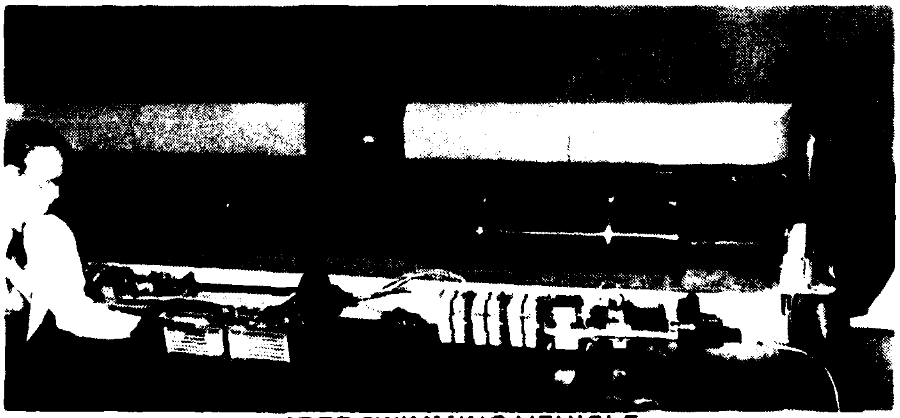


SUBMERSIBLE CABLE-ACTUATED TELEOPERATOR (SCAT).

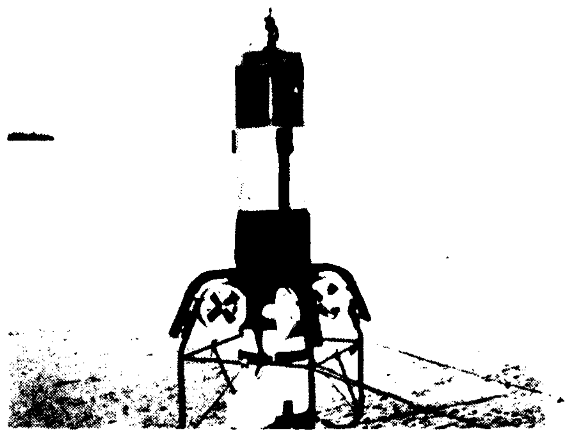
ELECTRIC SNOOPY.



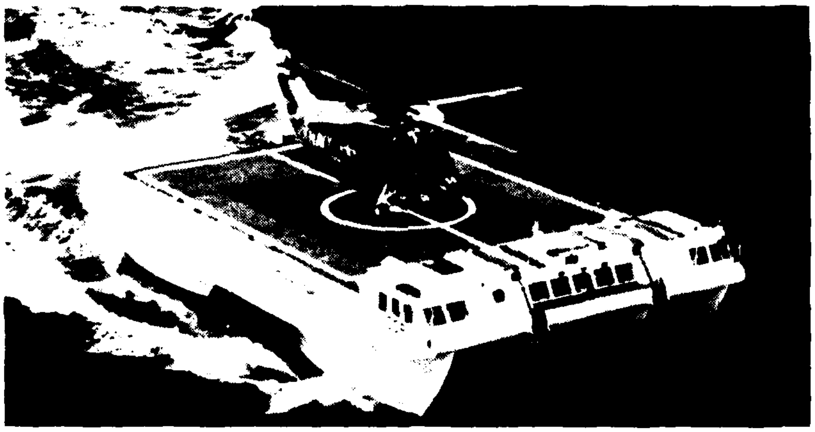
NAVFAC SNOOPY.



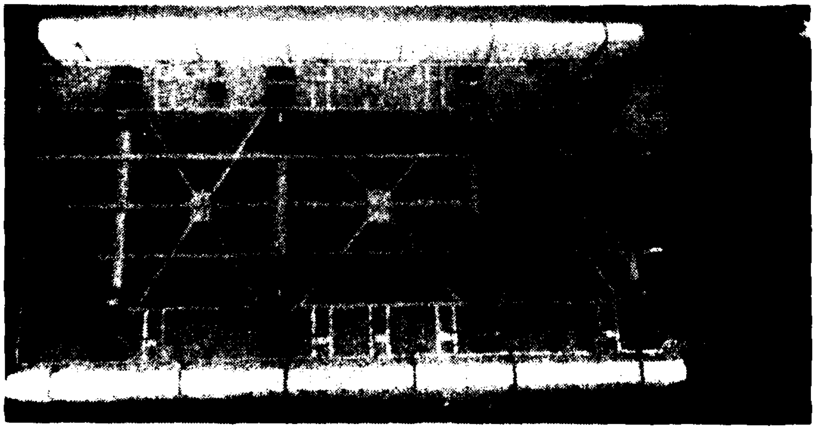
FREE-SWIMMING VEHICLE.



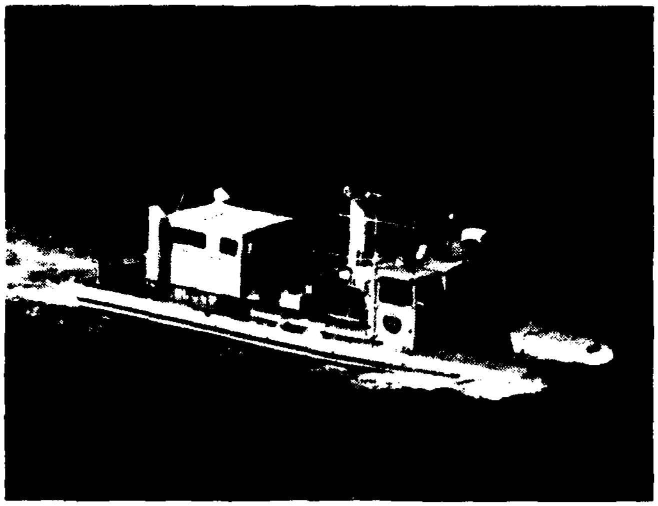
SOLID ROCKET BOOSTER DEWATERING SYSTEM.



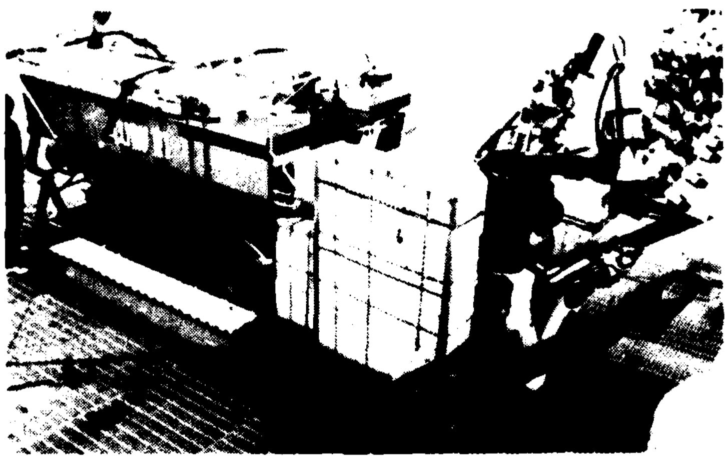
STABLE SEMISUBMERGED PLATFORM (SSP).



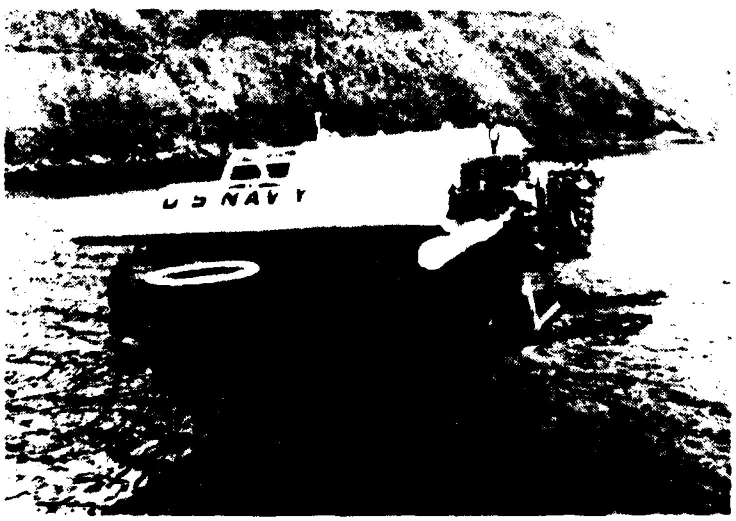
LAUNCH AND RECOVERY PLATFORM (LARP).



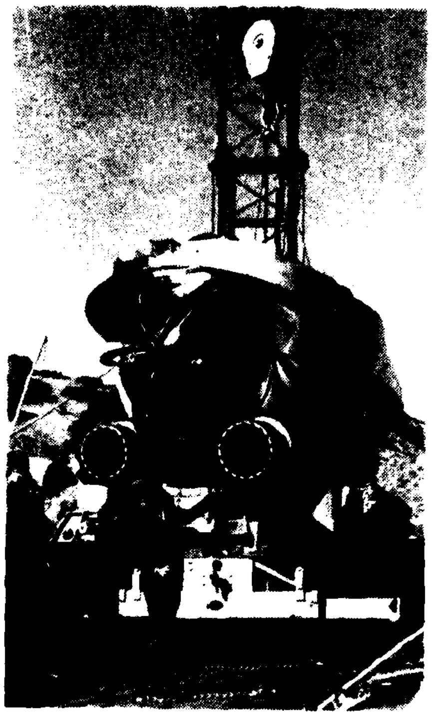
SEA-SEE UNDERSEA OBSERVATION PLATFORM



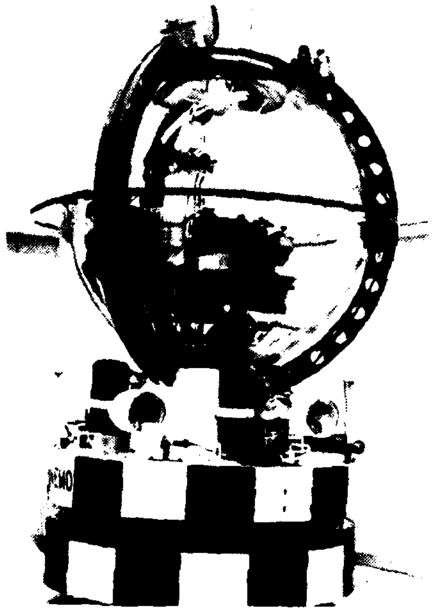
WORK SYSTEMS PLATFORM (WSP) (MOUNTED ON CURV III).



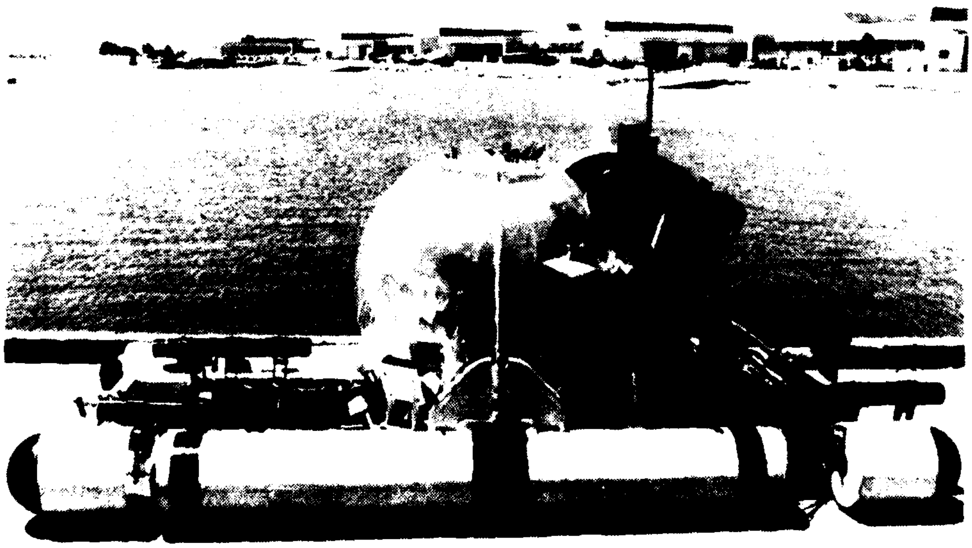
WSP MOUNTED ON PONTOON IMPLACEMENT VEHICLE (PIV)



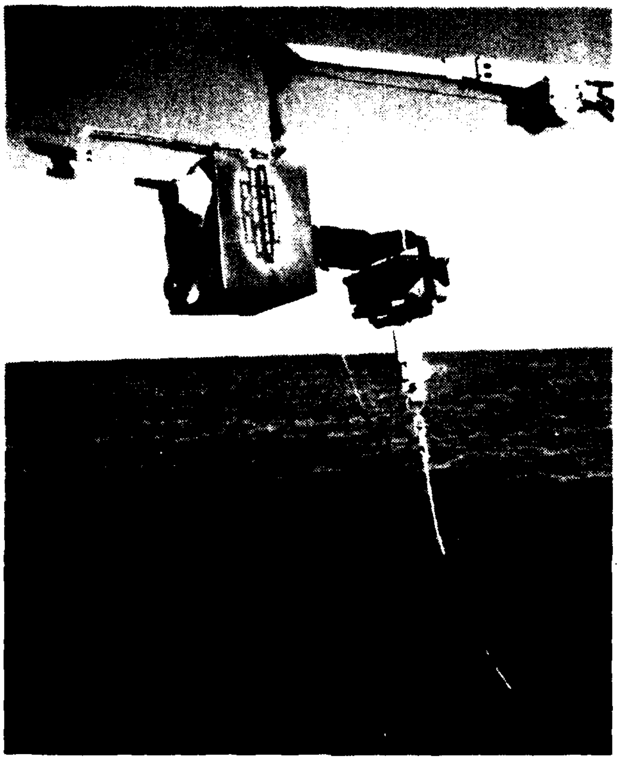
DEEPVIEW.



NEMO.



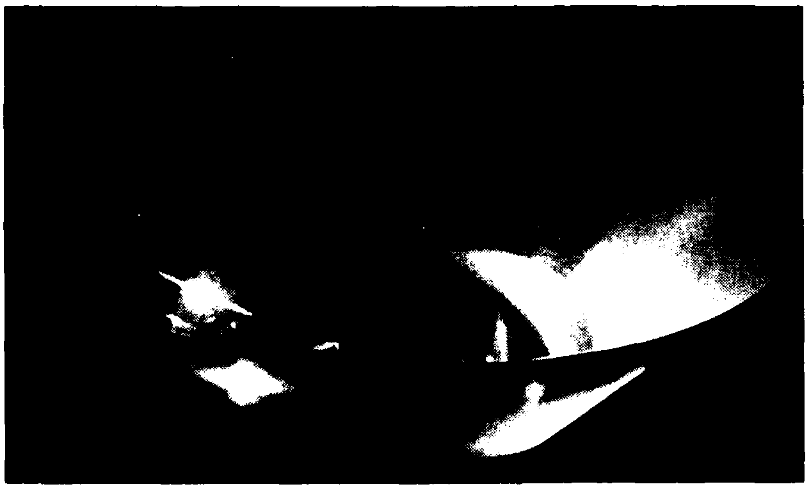
MAKAKAI.



BENTHIC UNTETHERED MULTIPURPOSE PLATFORM (BUMP)

SLOW-SCAN UNDERWATER TELEVISION IMAGE

IR WINDOW.



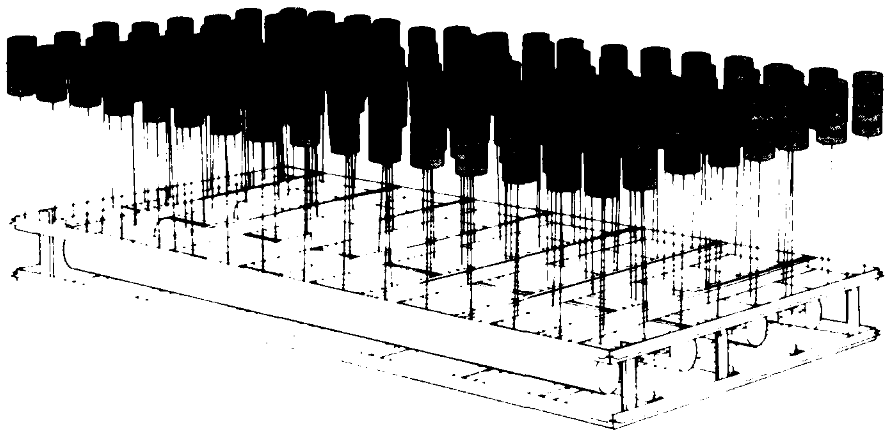
ACRYLIC WINDOW WITH
PANORAMIC VISIBILITY
FOR ALVIN.

7-FT ACRYLIC DOME FOR SSP

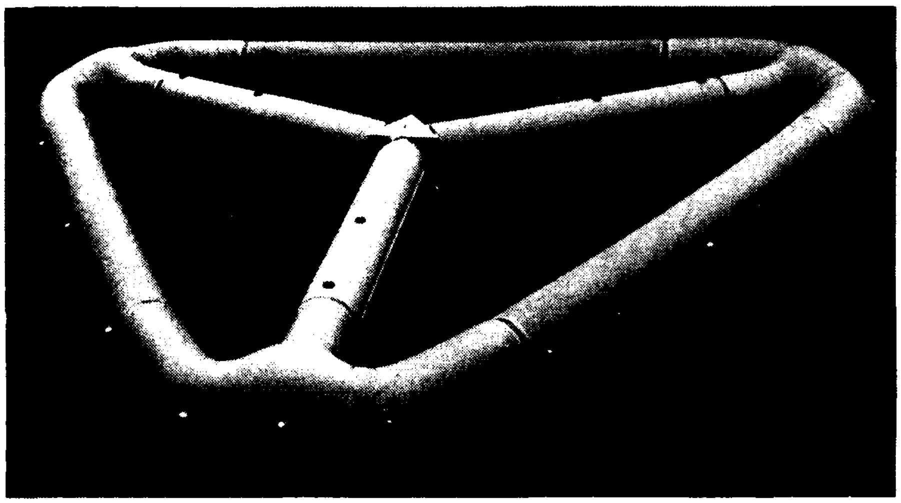
REAL-TIME OPTICAL MAPPING SYSTEM (ROMS).

ACOUSTIC IMAGING SYSTEM (AIS).

THE THIN, LIGHT FIBER OPTICS CABLE AT RIGHT REPLACES THE STANDARD CABLE AT LEFT.

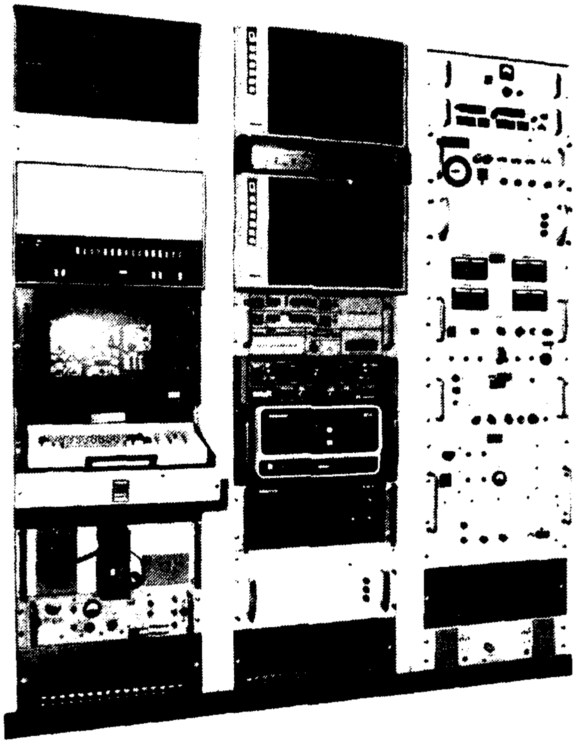


TETHERED FLOATING BREAKWATER SCHEMATIC

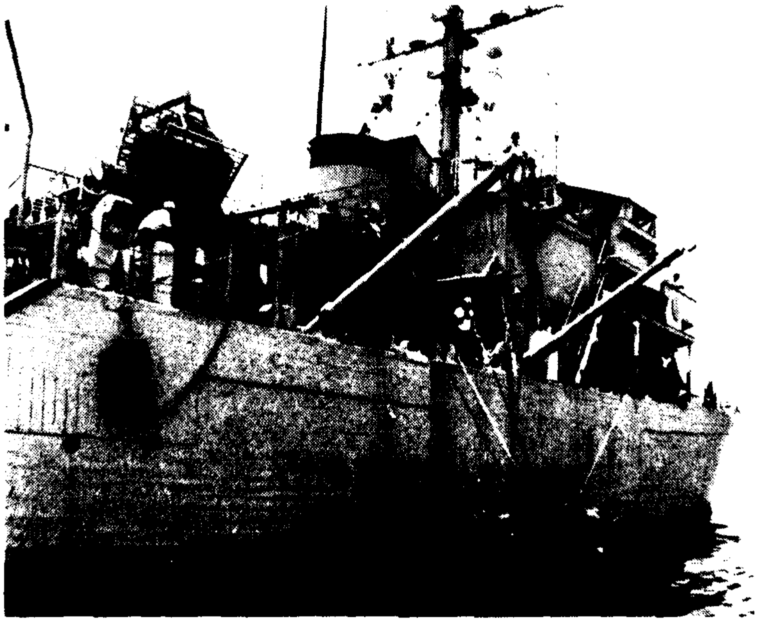


INFLATABLE ARRAY FOR ACCURATE POSITIONING OF ACOUSTIC TRANSDUCERS IN MULTISENSOR SONAR SYSTEMS.

ICING-UP OF PERISCOPE OPTICS IN POLAR REGIONS.

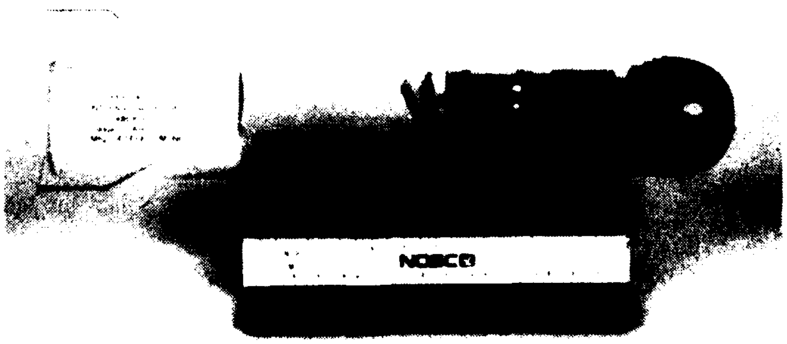


PRECISE INTEGRATED NAVIGATION SYSTEM (PINS)



MINE NEUTRALIZATION SYSTEM

CABLE CUTTER FOR MINE NEUTRALIZATION SYSTEM



OPTICAL OCEANOGRAPHIC DATA LINK FOR
EXPENDABLE SENSORS (OODLES)

SUCTION CUP RECOVERY DEVICE

The suction cup used as an experimental underwater recovery device has undergone evaluation tests at the San Clemente Island Test Range. The theory of operation is that a differential pressure is created around the surface of the cup when the unit is affixed to an object and the space inside the cup dewatered. The system has potential use both as a salvage device and as a holding or steadying fixture on items for underwater implantment or construction. The experimental model has successfully recovered objects weighing up to 2000 pounds from a depth of 20 feet in shallow-water experiments. The greater pressures at greater depths will enhance the effectiveness of this technique.

WATER LEVEL DETECTOR

The Water Level Detector is used to sense through the pressure hull of a sunken submarine and detect the presence or absence of water in its various compartments. This information is extremely useful during salvage operations. Neutron radiation techniques convey information through the submarine hull in a nondestructive manner. The source is an americium 241-beryllium, 50-millicurie pellet. The detector is a Texas Nuclear model 9325 neutron detector. A handle located on the side of the instrument energizes the electronics and, after a period of 1 minute, indicates whether there is water present. Depth capability of the equipment is 850 feet. The instrument operates on nickel-cadmium batteries which will provide power for about 8 hours.

HYDRODYNAMIC WINCH (Hydro-Winch)

The Hydro-Winch is a unique approach to the salvaging of very heavy loads from ocean depths through controlled lifting. The winch consists of a floating cylinder with watertight radial inner compartments. Water is transferred between inner compartments to cause the cylinder to revolve like a waterwheel. Close control of lowering, lifting, and holding operations is provided through the operation of the pump and control valves. The outer surface of the cylinder serves as a winch drum, unreeling cable during lowering and reeling cable in during lifting. The moment arm due to the cable wraps on the outside of the cylinder provides a large mechanical advantage. The line tension is automatically protected from overload by the fact that the floating cylinder is in no way restrained except by the amount of water in the radial compartments, which provides a constant load. A concept has also been evaluated in which the cylinder could be used to free grounded ships. This alternate arrangement would transfer the lifting forces to a horizontal direction to pull stranded ships free in shallow water.

SONODIVER

Deep-ocean instrumented buoys play diverse roles in the exploration of hydrospace. One of the more typical configurations of a deep-ocean instrumented buoy is a gravity/buoyancy-actuated instrumentation capsule such as the Sonodiver buoy. The Sonodiver buoy is an unmanned, untethered, deep-diving vehicle designed to operate as an acoustically quiet platform. The cigar-shaped buoy is 11 feet long, 18 inches in diameter, and weighs 450 pounds in air. The vehicle gathers acoustic and environmental data at predetermined ocean depths to 20 000 feet. Equipped with an omnidirectional hydrophone and environmental sensors, the Sonodiver records acoustic data between 10 and 5000 Hz and auxiliary data such as depth, velocity, and temperature.

Vehicle support equipment consists of fluid valves, weight-release mechanisms, flotation apparatus, fluid ballast, and a retrieval system. Although gravity/buoyancy control of depth uses a rather simple system, accuracy in following programmed courses requires high quality in design and fabrication.

REMOTE UNMANNED WORK SYSTEM (RUWS)

Under the Deep-Ocean Technology (DOT) program, NOSC has been developing the technology base necessary for performing engineering and scientific tasks in the deep ocean. The development and testing of the Remote Unmanned Work System (RUWS) has provided a major contribution to this technology base. The RUWS program stressed operational versatility in its design to accommodate a variety of missions, such as recovery, repair, implantment, survey, documentation, and oceanographic data gathering. The work unit of the RUWS, the vehicle itself, has a high-resolution, preformed-beam Vehicle Search Sonar (VSS) for performing local-area search and obstacle avoidance and passive directional hydrophones for pinger tracking and homing. Real-time, black-and-white, 525-line-resolution television provides visual data to the operator, while a 70-mm still camera can be used for photographic documentation. The TV cameras are mounted on a pan-and-tilt unit which can be manually controlled or used in a head-coupled mode, in which the TV cameras are slaved to the operator's head motions, thereby providing him with a distinct sense of being present at the work site. The work is performed by a two-arm manipulator system: one a relatively simple four-function, rate-controlled heavy grabber, and the other a seven-function, position-controlled, highly articulated manipulator for which special tools have been designed.

The system's primary cable connects the surface controls to the RUWS vehicle through a Primary Cable Termination (PCT) unit. The work vehicle is tethered to the PCT with a slightly buoyant, very flexible vehicle tether. A Motion Compensation Deck Handling System (MCDHS) performs the dual function of handling the vehicle and PCT during launch and recovery and reducing in-water motions of the PCT and dynamic loads on the primary cable. To simplify surface handling, the PCT and vehicle are launched and recovered by the MCDHS while mated together piggyback fashion. At operating depth, the vehicle is undocked and, on command, the vehicle tether is reeled in or payed out from a storage reel on the PCT. The command center for the RUWS operations is contained in the control van and includes controls and displays for the work vehicle and the PCT, as well as real-time navigation CRT displays. The objective in developing this system was to provide a test bed on which new concepts involving advanced technology can be tested and validated. The results of this new technology will provide the means whereby man's work capability may be extended to 20 000 feet, thereby providing access to 98 percent of the floor of the oceans.

PONTOON IMPLACEMENT VEHICLE / WORK SYSTEMS PACKAGE (PIV/WSP)

The Work Systems Package (WSP) was designed to enable the Navy to conduct operations, including salvage, recovery, installation, and repair, in ocean depths to 20 000 feet. The first work tools developed specifically for remote underwater operations were integrated into a modular package that allows quick installation on several submersibles. The WSP was designed for use with the CURV III and RUWS unmanned vehicles and the ALVIN, SEA CLIFF, and TURTLE manned submersibles.

Three simplified manipulator arms handle the tools, perform the work functions, and steady the vehicle. The central manipulator is a seven-function arm that offers considerable dexterity for handling the tools. The two outer arms have no elbow function and act as "grabbers," or restraining and holding arms.

Tools included in the storage box perform cable cutting, synthetic line cutting, nut torquing, jacking, wire brushing, sawing, grinding, drilling, tapping, chipping, and stud driving. Most are hydraulically powered, but the stud drivers and cable cutters are velocity powered. All operations are controlled through a multiplexed telemetry circuit from the vehicle. The major system components or the entire package can be jettisoned from the submersible vehicle if a serious emergency arises.

Since initiation of sea trials in 1975, the WSP has successfully operated with CURV III off San Clemente Island (SCI) and with RUWS in Hawaii and Florida. In 1979, it was mated with the Pontoon Implacement Vehicle (PIV) for testing in recovery operations off SCI. The PIV is an unmanned submersible precisely controllable via cable and equipped with television and lights. At-sea testing, supplemented by laboratory studies, has provided the foundation for the development of more advanced undersea work systems.

TECHNOLOGICAL APPLICATIONS

Ideas, designs, and products of other DoD activities and industry are constantly being reviewed in the light of Navy requirements. Under current study are such things as a proposed very large deep-sea sensor array and the use of directional hydrophones to improve passive sonar performance. In the past, investigations were conducted concerning the applicability to naval operations of such developments as synthetic materials for ropes and couplings and water-inflated fabric tubes for sensor array structures.

CURRENT PROJECTS

DUMAND—A LARGE DEEP-OCEAN NEUTRINO DETECTOR

DUMAND (Deep Underwater Muon and Neutrino Detection) is the name of a project started by a group of US physicists for the purpose of making a detector large enough to detect a significant rate of infrequent neutrino interactions, at energies beyond those available even from contemplated future particle accelerators. DUMAND may allow the observation of extraterrestrial and possibly extragalactic sources of neutrinos.

The techniques available for detecting high-energy neutrino collisions in the ocean utilize either the light flash the particles produce (Cherenkov radiation) or the acoustic pulse they emit (by instantaneously heating a tiny volume of water). The ocean is simultaneously the target, detection medium, and shield from external disturbances. The detector, at 3000 fathoms, will probably consist of vertical strings of sensors anchored to the bottom and buoyed. They will be connected by cable to shore. The array will have variable spacing on the strings, with sensors from 20 metres apart near the center to 160 at the

periphery, initially encompassing a volume of 1 cubic kilometre (and in the ultimate version perhaps 100 cubic kilometres).

The program is in active development now, with research going on at many laboratories and in the ocean near Hawaii. NOSC's primary contribution to the study effort to date has been associated with the ocean engineering aspects of the array and the selection of a suitable deep-ocean site. Supporting studies, preliminary designs, and cost estimates have been generated addressing the important areas of sensors, cabling, signal processing, and installation and maintenance of the array structure. The concept of a small unmanned vehicle which would be dedicated to remote maintenance of the array is being investigated.

ACOUSTIC DATA COLLECTION

The aim of this project is to provide a means of detecting and signaling the presence of whales in the vicinity of the Kaula Rock (Hawaii) aerial bombing range so that they may be protected from injury or destruction. As a first step, a monitoring system is being installed that will be capable of detecting whales acoustically and communicating this information by radio to a station on the island of Kauai.

The system is planned to operate unattended for 6 months and cover all areas around Kaula Rock. Detection will be accomplished by hydrophones suspended 100 ft below two buoys anchored in 150 feet of water. Each buoy will be equipped with a 40-dB, low-noise preamplifier; a 60-dB-per-octave high-pass filter (100-Hz cutoff); a 60-dB AGC hydrophone amplifier; a radio transmitter; and a power source.

The systems will be designed to have a frequency response of ±3 dB in the range 100 Hz to 3 kHz and be sea-noise limited over the usable bandwidth. The automatic gain control feature of the hydrophone amplifier will permit low-level sounds to be heard while protecting the system from saturation by high levels. The final filter section will limit the bandwidth in order to achieve efficient radio transmission.

The power source will be standard buoy batteries. The preliminary requirement appears to be for a capacity of 3500 ampere-hours, using 12-volt batteries.

The two buoys will be placed to yield 360-degree coverage around Kaula Rock. There will be some overlap of hydrophone coverage in the north and south quadrants, but none in the east and west. This arrangement will permit azimuthal location of sound sources to within ±80 degrees.

CABLE TECHNOLOGY HANDBOOK

The use of new materials and manufacturing techniques has produced undersea electromechanical cables having greatly improved operating characteristics. However, much of this new cable technology is unpublished or given "proprietary" protection and is, therefore, inaccessible to many potential users. The goal of the project, which will be conducted jointly by NOSC, the Naval Underwater Systems Center, and Civil Engineering Laboratory, is to gather information from industry and Navy sources and to compile a handbook that will serve as a guide to the design, production, and use of advanced undersea cables. Included will be detailed presentations of cabled system concepts, materials, design, analysis techniques, manufacturing and testing capabilities, and environmental factors. Sufficient information will be provided to form the basis for computer-aided analyses and tradeoff studies, particularly in such areas as finite-element analysis and modeling. Thus the handbook will offer state-of-the-art guidance to designers of such equipment as surveillance systems, tethered submersibles, and communications systems, all of which employ undersea cables. It is anticipated that the handbook will be furnished to companies responding to requests for proposals (RFPs) involving undersea cabling.

OCEAN ENGINEERING HANDLING SYSTEM

The Ocean Engineering Handling System task is a broad-scope investigation which acquires and organizes data applicable to the surface handling problem. Launch and retrieval of submersibles, including Personnel Transfer Capsules, is emphasized as well as the emplantment or recovery of objects from the sea floor and recovery of objects from the sea surface. Handling system components will be identified and characterized in a manner that will allow total system dynamic analysis. This information will be compiled in a handbook to serve as an aid to designers and operational planners throughout the Navy.

DIRECTIONAL SENSOR

In connection with the development of a directional hydrophone by the Naval Electronic Systems Command, NOSC was asked to evaluate the impact such a device would have on the performance of underwater acoustic arrays. A scheme was developed to realize a directional response of $(1 + \cos\theta)$ for such hydrophones. Various data sets (including signals, signals plus noise, and broadband data) were played through the system to validate its response. The hydrophone was modeled, and its contributions to beam directivity in general and to array performance in specific locations were evaluated. Results indicate that, for linear arrays, significant performance gains can be

realized through elimination of the back beam by utilizing directional sensors.

PAST ACHIEVEMENTS

SYNTHETIC FIBER ROPE PROGRAM

Since the introduction of man-made fibers such as Nylon, Dacron, and polypropylene, synthetic fiber ropes have become available for use aboard ships. These ropes are superior to natural fiber ropes in strength, wear, and resistance to rot, decay, and marine fungus. However, the methods of handling natural fiber ropes do not directly apply to the synthetic ropes, and disregard for the different physical and mechanical properties can cause damage and, occasionally, fatal accidents.

The rendering quality of the synthetic ropes—that is, their ability to move smoothly over bitts and capstans without sticking or chattering—is of fundamental interest and importance in marine applications. A good knowledge of the predominant factors, such as friction and surface melting, is essential in developing effective handling techniques and preventing accidents, excessive surface melting, and premature failure. NOSC is acquiring data to determine the static and sliding friction coefficients of synthetic ropes on bitts and capstans and the effects of surface heating on different rope diameters.

COUPLING FOR SYNTHETIC ROPE

The introduction of synthetic fiber rope into the Fleet has resulted in coupling failures. Analysis by NOSC shows that couplings designed for use with manila rope are subjected to severe overloads when used with synthetic fiber rope. As a result of this analysis, NOSC has designed and tested a new coupling to be used for mooring and towing and which has sea anchoring capabilities. To be manufactured from HY-100 steel or titanium, this coupling will eliminate structural failures, handle rope of larger size, and permit tow speeds to be increased from 4 to 8 knots. This coupling has been accepted for Fleet use and authority issued for conversion.

INFLATABLE ARRAY FRAMEWORK

Detection and location of distant acoustic targets by passive listening requires that hydrophones be held in a predetermined spatial arrangement. Typically, hydrophones are placed on a network of buoy-supported cables which are held taut by properly placed anchors. The disadvantages of this approach are that it requires a large number of ships and many man-hours. To overcome these problems, an alternate

approach has been developed which utilizes water-inflated fabric tubes to support the hydrophones. The inflation of the fabric tubes is an autonomous process that, once initiated, requires no further assistance from divers or ships save for the placement of additional anchors for very large arrays. An exploratory study conducted using three shapes and three fabrics has shown that this approach is feasible and does indeed minimize the need for surface support. In fact, listening arrays less than 500 feet across can be deployed without surface support.

FIXED ENDFIRE SURVEILLANCE ARRAY—BARRIER LINE

The objective of the Fixed Endfire Surveillance Array—Barrier Line (FESABLE) program was to demonstrate a lightweight, easily deployable, shallow-water acoustic surveillance capability. The approach taken to realize this capability was design and fabrication of an endfire acoustic array with randomly spaced hyrophones. All hydrophone amplifiers and beamforming electronics are at the array (wet end). The power to the array electronics and the signal from the array are carried on a single cable running from the array to shore. A seawater return completes the circuit.

The weight of the 41-hydrophone array and its processing electronics is slightly in excess of 200 pounds. The 18 000 feet of single-conductor shore cable weighs slightly over 100 pounds. The entire array, including shore cable, has been laid from a single 18-foot outboard motor boat (a Boston Whaler).

This array operates in the frequency range below 300 Hz. Its depth capability is limited only by the length of the cable required to reach shore. With first-generation array electronics, this limit is about 35 000 feet.

AIR-FILM TECHNOLOGY

The air bearing is a device in which low-pressure air continuously inflates a flexible diaphragm while a thin film of air escapes through small vents in the diaphragm, providing a frictionless surface on which the bearings ride. The capacity of a bearing equals the pressure times the support area: a bearing with an airflow of 8.85 psi and a 24-inch diameter has a capacity of 4000 pounds. Some of the promising specific applications of air bearings already considered include handling of equipment and vehicles aboard amphibious ships, unloading cargoes directly on a beach by use of surface mats, and bearings for gantry cranes.

INTER-SEAMOUNT ACOUSTIC RANGE (ISAR)

The Inter-Seamount Acoustic Range (ISAR) was established as part of a 3-year study of how sound propagation in the ocean is affected by environmental factors. ISAR involved two separate installations: the transmitter, located atop the San Juan Seamount some 200 miles off the Southern California coast, and the receiver, moored over the Westfall Seamount about 200 miles south of the transmitter and west of Baja California.

The transmitter consisted of four low-frequency sound projectors in a buoy-supported vertical line array above a structure containing the necessary electronics and a power source, including a nickel-cadmium battery pack continuously charged by a radioisotope thermoelectric generator. Appropriate placement and recovery lines were installed nearby. Programmed to send a 10-minute sequence of long and short signals every 4 hours, the transmitter operated unattended for more than 3 years after it was installed in June 1969.

The receiver consisted of hydrophones and a large spar buoy in a three-point, taut moor over the Westfall Seamount. The data-gathering hydrophones were arrayed beneath the buoy in U-moors. Once a day, on command from shore, the data recorded at the buoy were transmitted to NOSC, San Diego, via rf link.

The receiver was removed from its installation site in 1972. The transmitter was recovered from the Seamount in July 1976 with the aid of the unmanned submersible CURV III. The nuclear power source was still operating, but at a predictably reduced power level.

PLATFORMS

The Navy, constantly seeking to incorporate greater stability and operational flexibility in the construction and application of its ships, is exploring the feasibility of stable ocean platforms. In order to keep pace with continuing submersible development, expanding ocean engineering capabilities, and changing logistics requirements, both stationary and self-propelled platforms that reflect advances in hull design and materials technology have been proposed. Having overcome the deleterious effects of wave action energy, stable ocean platforms of varying sizes and configurations can meet the growing needs of sea-based operations. These applications may include such uses as sea control ships, undersea surveillance platforms, tactical air bases, submersible depots, offshore docking facilities, and floating cities.

CURRENT PROJECTS

SWATH SHIP

It has long been a goal to develop ships that, at rest or underway, exhibit small motions and accelerations in large waves. Since 1968 NOSC has been active in the development of such a concept, the small-waterplane-area twin-hull ship (SWATH).

Because of SWATH's small waterplane area, passing waves produce only a fraction of the buoyancy change of a conventional monohull, resulting in significantly less motion. Also, whatever motion does occur can be further reduced when underway by the use of active fin control, since the small waterplane area makes possible near-full control over heave, pitch, and roll. Furthermore, since SWATH's draft is greater than that of a monohull and the flow into the propellers is more uniform, there is a tendency toward less propeller cavitation and quieter, more efficient propeller operation. Even at rest, or underway at low speed, the small waterplane area, combined with the spread-out configuration, the twin torpedolike lower hulls, and fin appendages, produces much less motion in waves than does a monohull.

NOSC activity in the SWATH ship development area has centered around three main areas: exploration of the basic concept, advancement of SWATH technology, and assisting in introducing a SWATH ship into the Navy. This has encompassed a broad spectrum of work, including designs of new SWATH platform configurations, theoretical analysis and model testing, and advanced SWATH design concepts. Full-scale SWATH testing and demonstrations have been significantly aided by the NOSC range support platform, the SSP KAIMALINO, a 225-ton-displacement SWATH ship.

The significant reduction in ship motion associated with SWATH-type hulls, compared with conventional hulls, has been well documented. How this motion reduction affects crew performance has yet to be ascertained. Current research studies are being conducted to derive functional relationships between ship motion and a variety of cognitive, psychomotor, and physiological measures. The results of these studies will provide valuable information for operators in planning deployments with existing vessels and may significantly influence decisions for development of SWATH ships for the Navy.

SSP KAIMALINO

The SSP KAIMALINO was developed by NOSC to fulfill the requirements for a range support craft for use in typically rough ocean water off the NOSC Hawaii Laboratory. The SWATH configuration was

selected for the KAIMALINO's design because it offered the combination of features only SWATH could provide: large usable deck areas and internal volume, and small accelerations and motions in rough seas over a wide range of speeds.

The SSP has now logged several thousand hours at sea conducting a wide variety of tests, demonstrations, and range support operations in sea states up to 6. In addition, helicopter operations, in up to sea state 4 have been performed. The SSP is 89 feet in length and 45 feet in width and has demonstrated a top speed of 25 knots using twin gas turbines for primary propulsion. At its cruising speed of 16 knots, the SSP has a range of 450 nautical miles. An automatic motion-control system is used to provide input signals to activate flaps and canard control fins to provide near-level ride conditions in very rough seas. Automatic heading control and low-speed auxiliary propulsion provide excellent transit navigation and position-keeping for deployment of hardware, instrumentation, or submersibles.

Efforts are now underway to enlarge the SSP in order to provide sufficient payload capacity, endurance, and accommodations to allow open-ocean demonstrations of towed array operations. Displacement will be increased from the present 225 tons to 610 tons. This modification is expected to be completed in the first quarter of 1982, with demonstration following during the summer of that year.

BUMP (BENTHIC UNTETHERED MULTIPURPOSE PLATFORM)

BUMP is a versatile instrumentation package designed to function below the surface. It is positively buoyant and is made to sink by weights attached to a line of suitable length connected via its transponder/acoustic command release. Upon command, the weights are released and BUMP will pop up to the surface for recovery. Backup release mechanisms employ a timing device and the corrosive action of seawater. A pinger and transponder are used for acoustic location of the submerged platform; a radio frequency beacon and flashing light facilitate locating it on the surface. The remainder of BUMP equipment includes a block of syntactic foam (to provide buoyancy), an electrical bottle, whose interior is maintained at atmospheric pressure, and a pressure-equalized battery pack to power the electronics. Although BUMP was developed for acoustic telemetry tests, it is readily adaptable to other applications.

BUMP measures 27 by 72 by 29 inches and has a weight in air of 850 pounds. Its maximum operating depth is 16 000 feet. The volume enclosed by the electronics bottle is 1 cubic foot, and the battery has a capacity of 48 volts at 30 ampere-hours (1440 watts per hour). BUMP's payload (positive buoyancy) is 100 pounds.

PAST ACHIEVEMENTS

FLOATING STABLE PLATFORM

NOSC has demonstrated the feasibility of building a modular Floating Stable Platform by extensive hydrodynamic and utilization model studies. With a small waterplane area and a large, massive, buoyant base, the platform achieves the much-needed stability for safe, efficient operations at sea. Unlike the hull of a displacement vessel (tugboat, destroyer, etc), which is constantly affected by the surface wave action, the large buoyant base is well below the surface wave action and very stable. The surface of the platform is well above the energy of the wave action. The modular approach permits great versatility. The fabrication of the basic platform module could be accomplished by using concrete — a low-cost, malleable material — and repetitive forms. Once fabricated, the modules can be arranged in any number of useful configurations. Each project could select a configuration which best meets its immediate need. Some possible uses of the Floating Stable Platform include tactical air bases, municipal airports, nuclear power sites, offshore docking facilities, undersea construction bases, offshore industrial sites, and floating cities. These applications are not only feasible, but practical and economical as well.

OBSERVATION PLATFORMS WITH PANORAMIC VISIBILITY

Shallow-water observation platforms have been instrumental in the advancement of present-day marine biological research. They have provided the researcher with an unhindered view of the shallow-ocean environment. In addition they have provided a means by which the oceanographer/scientist can obtain first-hand data without the inherent constraints and limitations imposed by the use of diving apparatus.

CURRENT PROJECT

SEA-SEE

An innovation in near-surface underwater observation is the research catamaran SEA-SEE. The unique feature of SEA-SEE is an observation compartment which can be lowered between the pontoons of the catamaran to a depth of 10 feet. The ends of the compartment

are hemispheres of clear plastic, which provide unrestricted views for photography and other research observations. The capsule has seats for two observers. When the capsule is lowered, eye level is at a depth of 6 feet. SEA-SEE has deck-level accommodations for a working complement of up to four scientists and a crew of two. With its range (300 miles), equipment, and observation compartment, SEA-SEE provides a convenient platform for complete views of coastal and near-surface marine life, activities, and environments.

PAST ACHIEVEMENTS

OCEANOGRAPHIC RESEARCH TOWER / ACRYLIC ELEVATOR

NOSC designed and installed a permanent oceanographic research tower in shallow water (60 feet) approximately 1 mile offshore from Mission Beach, San Diego, California. The stable platform assures continuous oceanographic and meteorologic measurements from a fixed location. Special equipment was designed to support research performed from the tower. Vertical railway tracks on three sides of the the 85-foot tower allow instrument carts to be positioned at any level down to the sea floor. The tower has overnight accommodations for six people.

An underwater, 1-atmosphere, manned acrylic elevator was developed to enhance the versatility of the tower. The elevator can accommodate the operator and one passenger for the descent through the 60-foot water column to the ocean floor. The elevator "cage" is a transparent acrylic sphere that provides a panoramic view of the surrounding water. The sphere, which is 5 feet in diameter, is a product of the transparent hull technology developed at NOSC. The system has been removed from the tower and is in storage at present.

HULL INSPECTION PLATFORM (HIP)

The Hull Inspection Platform (HIP) is a one-man capsule designed at NOSC to provide a shirt-sleeve, 1-atmosphere environment for inshore marine investigation and engineering. The vehicle consists of a twin-pontoon floating support platform on which is mounted an articulated arm with an observation platform. The device is capable of placing an observer to a depth of 20 feet within close proximity of a subject for investigation. This unique tool eliminates the need for shallow-water diving support in many instances. During operations, the compartment is raised to the deck of the support platform for ingress/egress, stowage, and maintenance. The HIP concept lends itself to direct supervision of all phases of marine investigation.

SUBMERSIBLES WITH PANORAMIC VISIBILITY

Small, agile submersibles with panoramic visibility have been found to be ideal vehicles for carrying men and equipment on reconnaissance and sea-floor missions. Recognizing this fact, NOSC has pursued programs for their design, fabrication, and utilization. The products of these programs are several systems that differ in concept, structural materials, mobility, and application. All provide panoramic visibility underwater and at small cost in terms of the size and complexity of supporting equipment.

PAST ACHIEVEMENTS

NAVAL EXPERIMENTAL MANNED OBSERVATORY (NEMO)

The Naval Experimental Manned Observatory (NEMO) is a self-contained submersible with a 1-atmosphere environment. The vehicle has been Navy-certified for an operating depth of 600 feet and carries a crew of two (an operator and an observer). In addition to the crew, the vehicle can carry a payload of 450 pounds. The pressure hull is constructed of acrylic plastic and has an outside diameter of 66 inches with a wall thickness of 2½ inches. The spherical hull is supported by a structural cage. The cage serves two functions: it supports the weight of NEMO and also provides a shield which protects the acrylic sphere from impact loads. Directly below the cage is a unit containing the main ballast tank, service module, and main battery pack. The vehicle has several modes of operation. It can take on ballast and make a free descent or can drop its anchor and winch itself down. Because of this self-contained anchor and winch system, the NEMO can hover in the water column at any depth and with low power consumption. The vehicle has a vertical speed of 30-60 feet per minute and a life support system of 64 man-hours. NEMO was developed by the Civil Engineering Laboratory, Port Hueneme, California, and is now on loan to Southwest Research Institute.

DEEPVIEW

DEEPVIEW, a two-man submersible with a transparent bow developed by NOSC, is the first submersible to incorporate glass as a significant portion of the pressure hull. Because its operational depth capability potentially exceeds that of acrylic hulls, glass was selected as the material for transparent hull development. This use of glass

represents a technological breakthrough that provides oceanographic investigators with maximum visibility in the undersea environment.

The glass hemisphere serves as the forebody of an HY 100 cylindrical midhull stiffened with rings, while the aft end is a steel hemisphere containing the electrical pass-throughs and hatch. The 16.5-foot, torpedo-shaped DEEPVIEW weighs almost 6 tons. Having a mission endurance of 6 hours, the submersible was Navy-certified for a depth of 100 feet. Two 5-horsepower motors provide a submerged cruising speed of 1–3 knots and a surface speed of 5 knots. Thus equipped, DEEPVIEW is a small, versatile submersible capable of performing undersea tasks requiring maximum visibility. It is currently on loan for display at the Museum of Science and Technology in Chicago.

MAKAKAI (Eye of the Sea)

MAKAKAI, a transparent-hull submersible, is a two-man, free-swimming vehicle developed and built by NOSC. It has a Navy-certified operational depth of 600 feet and utilizes an acrylic sphere as the pressure hull. This affords the operator and the passenger an unobstructed, panoramic view of the surroundings. The pressure hull is mounted on a frame to which two pontoons are secured. The pontoons house the lead-acid batteries used for the power supply. Each pontoon contains tanks that are used for ballast and trim during diving operations.

MAKAKAI is propelled by two sets of oppositely arranged, cycloidal-thrust units which provide a cruising speed of 0.5–0.75 knot with a maximum speed of 3 knots. In addition, the thrusters provide 4 degrees of freedom for the vehicle by altering the pitch of the propeller blades. The vehicle has a payload of 870 pounds, including the crew, and can support a mission of 8 hours duration. MAKAKAI is presently on loan to Sea World, Inc.

DEEP SUBMERSIBLES FOR RESCUE, SEARCH, AND SALVAGE

The Navy has long recognized the need for deep-diving submersibles to carry out missions of search, rescue, and investigation. Accordingly, it has assisted in the development of submersibles that

function from mid-ocean depths to 20 000 feet, thereby providing access to approximately 98 percent of the ocean floor.

CURRENT PROJECTS

TURTLE AND SEA CLIFF

TURTLE and SEA CLIFF, operated by Submarine Development Group 1, San Diego, California, are two of the Navy's versatile, deep-diving research submersibles. The TURTLE has an operating depth of 10 000 feet, the SEA CLIFF 6500 feet. The SEA CLIFF is currently being modified to operate at 20 000 feet. These self-propelled vehicles are designed for search, work, recovery, and exploration. Each is 26 feet long and weighs approximately 21.5 tons. Primary power is provided by lead-acid batteries. Designed to operate at a maximum depth for sustained periods, each vehicle with its crew of three can maneuver underwater for approximately 10 hours at a speed of 1.5 knots while conducting normal search operations. Navigation equipment provides personnel in the sphere with such information as distance to the surface, bottom depth, speed, distance covered, and true compass readings. The vehicles are fitted with a sonar system, underwater telephone, and a radio communications system. Equipment designed to enhance mission capabilities includes closed-circuit television, transparent viewports, and lights for illuminating the area around the vehicle and the ocean floor. The vehicles are also fitted with a pair of articulated arms, or manipulators, which have a complement of tools for cutting, drilling, and grasping. Mounted on the forward end of the vehicle, between the manipulators, are baskets that can hold tools as well as small objects recovered from the ocean floor. NOSC is presently assisting Submarine Development Group 1 to improve the reliability and operational capability of TURTLE and SEA CLIFF by coordinating most of the alterations and repairs to be accomplished in the San Diego area.

SUBMARINE RESCUE UNIT (SRU)

The submarine Rescue Unit (SRU) is a facility on the North Island Naval Air Station, where the Deep-Submergence Vehicles (DSV) TURTLE and SEA CLIFF and the Deep Submergence Rescue Vehicles (DSRV) AVALON and MYSTIC are homeported. NOSC is currently coordinating an effort to increase the on-site maintenance capabilities of the SRU.

DSRV OPTICS PROGRAM

The objective of this program is to define, specify, procure, test, improve, and support the optics systems of Deep-Submergence Rescue Vehicles (DSRV 1 and 2, MYSTIC and AVALON) as well as those of the mother submarine.

Teamed with vendors, NOSC has been resolving problems associated with optical systems, including television cameras and lights, pan-and-tilt mechanisms, still cameras, and viewport optics systems. Environmental tests have proven structural integrity.

Statistics are being obtained to establish failure rates. The resulting equipment designs may be used on unmanned or manned submersibles for classification and observation tasks related to reconnaissance, salvage, construction, and rescue missions.

Initially, NOSC laid out an optics suite designed to provide adequate underwater viewing during a rescue mission. Tests conducted at San Clemente Island showed that the suite provided the required optical coverage. Field test data were compared with analytical results to predict viewing capabilities (range and resolution) for a variety of ocean conditions.

Continuing field and repair support is being provided for the optics equipment being utilized by the DSRVs. Required field changes are identified and engineering solutions to the problems are proposed. Upon approval, these field changes are incorporated into the optics equipment program and installed on board the submersibles.

SIMULATED DISTRESSED SUBMARINE

The Simulated Distressed Submarine (SDS) is a submersible structure simulating the upper half of the forward section of a submarine. The unit consists of four hydraulically operated legs, a hydraulically rotatable drum in the center section (which houses the simulated submarine escape hatch), buoyancy and ballast tanks, a removable frangible sail assembly, underwater closed-circuit TV systems, and still and motion picture cameras with associated lighting. This equipment is connected to a control console, located on shore, by means of a power and instrumentation cable. The unit is raised and lowered by means of the buoyancy and ballast system and a shore-mounted winch rigged to a sea-floor-mounted sheave. The SDS was designed for use in the DSRV Test and Evaluation Program. During operations, the SDS is "hauled down" to the ocean floor in a positive buoyancy mode. Once in place on the bottom, the ballast system is activated and ballast tanks are flooded. The unit has been designed to operate down to a depth of 200 feet.

PAST ACHIEVEMENTS

DEEP-SUBMERGENCE RESCUE VEHICLE

The Deep-Submergence Rescue Vehicle (DSRV) is a deep-diving submersible designed to mate with the hatch of a disabled submarine and take aboard the submarine's personnel. The DSRV weighs approximately 65 000 pounds in air and has a displacement of 76 000 pounds when submerged. It is powered by silver-zinc batteries and has a maximum speed of 4.5 knots. It has an operating time of 10 hours at cruise speed with a 30-percent reserve power supply. Maximum operating depth is 5000 feet. The DSRV can be launched either from a "mother" submarine or from an ASR 21 class Submarine Rescue Ship. During a rescue mission, the vehicle and its support equipment can be loaded on aircraft for "fly away" to a port nearest the disaster area. There, the vehicle can be loaded on either a "mother" submarine or an ASR for the rescue operation. The DSRV, through its many sensing devices, can locate the disabled submarine, mate with either the forward or the after hatch, and take aboard 24 of the sub's crew on each trip for transfer to the support craft. Two such vehicles are in operation under the cognizance of Submarine Development Group 1, Ballast Point, California. The vehicles were developed by NAVSEA PMS 395. NOSC is responsible for field test support.

TRIESTE

TRIESTE, the Navy's deepest-diving vehicle, is capable of carrying three men on scientific, search, and recovery missions to depths of 20 000 feet. In 1960, TRIESTE dove to 35 800 feet in the Mariana Trench.

TRIESTE is outfitted with a search sonar, manipulators, and a photographic suite. It has participated in the search and location of the submarines THRESHER and SCORPION and aided in the recovery of an aircraft.

Support during diving operations is provided from the floating dry dock USS POINT LOMA (AGDS 2). Operation, maintenance, and control are under the cognizance of Submarine Development Group 1.

NOSC has contributed modifications to TRIESTE's electronic, acoustic, photographic, and high-pressure systems and redesigned its superstructure gratings to make its topside equipment more accessible. Additionally, a new penetrator cable assembly was designed to eliminate leakage and grounding problems that had severely restricted TRIESTE's operational readiness.

LAUNCH AND RETRIEVAL OF SUBMERSIBLES

Sea-state limitation of present-day surface support systems to launch and retrieve submersibles is a handicap to operational forces in exploiting the full operational potential of undersea vehicles. Launch and retrieval operations can be made significantly simpler and less hazardous if the relative motion between the submersible and the launch platform can be reduced or eliminated. For this reason, a number of engineering solutions for expediting launch and retrieval operations have been formulated and implemented at NOSC.

PAST ACHIEVEMENTS

LAUNCH AND RECOVERY PLATFORM (LARP)

The Launch and Recovery Platform (LARP) is a 35- by 18-foot towed catamaran designed to provide a stabilized platform for underwater launching and recovering of submersibles. The vehicle can be lowered to a depth of 130 feet by surface support divers or remotely to 200 feet via a tethered power cable. LARP can be positioned in a hovering mode, at any depth between the surface and its operating depth, by means of buoyancy/ballast compartments located in the center of each pontoon. Other sections of the pontoons are utilized as ballast or buoyancy tanks during lowering and raising operations. Buoyancy blocks, mounted above the pontoons, provide added stability while the vehicle is under tow on the surface. Twelve high-pressure air flasks are mounted below the buoyancy blocks and supply the necessary air for deballasting. The vehicle can be disassembled in a day for fly-away operations and reassembled on site in 48 hours. It was initially designed to handle MAKAKAI and submersibles of similar size.

SEMISUBMERGED STABLE SUPPORT PLATFORM CONCEPT

In the operation of submersibles that are used for work, research, and observation tasks, NOSC has recognized the need for a low-cost support platform. This initiated a conceptual design effort for a versatile submersible-support platform.

The Semisubmerged Stable Platform is the product of applying NOSC's Stable Support Platform concept to the submersible-handling problem. This concept utilizes two parallel, torpedolike hulls submerged to a depth of about two hull diameters and attached to an above-water platform by four vertical struts. The twin hulls provide excellent static stability. Dynamic stability is supplied by a large righting-moment arm. The design combines the submerged hulls with a platform that has a large working area and center well. The Platform can be maneuvered over the submersible and recovery made via an elevator and gantry crane. The high freeboard keeps the main deck above the waves and dry even in rough seas. This design can provide a stable platform for launch and recovery of submersibles in conditions up to sea state 4. Thus weather contingency costs may be reduced and the submersible's operational capabilities enhanced.

HELICOPTER LAUNCH AND RECOVERY

A project was successfully completed to demonstrate the helicopter launch and recovery of a small submersible. This is one of several technologies needed to enable manned submersibles to operate independently of large surface support craft. Two approaches were used. In the first, a helicopter lifted the MAKAKAI from a pier to the deck of an underwater launch and recovery vehicle. The two were then towed to the operating area by a surface support craft. Upon completion of the mission, both were returned pierside, and a heavy-lift helicopter off-loaded the submersible.

In the second approach, a heavy-lift helicopter transported the submersible from the pier to the dive site. At the dive site, the helicopter lowered the submersible into the water, detached, and stood by to act as a surface support craft. Then the helicopter reattached to the lifting sling and recovered the submersible. Finally, the helicopter transported the submersible from the dive site to the pier.

This project established the feasibility of using a heavy-lift helicopter for the handling and transportation of small submersibles and other types of swimmer-delivery vehicles.

DIVING TECHNOLOGY

The Navy has long taken the lead in the development of diving technology. Advancements in the state of the art for divers' aids, training equipment, and techniques in physiology have enhanced man's ability to attain greater diving depths with greater safety and work efficiency. The following systems represent some recent advances.

PAST ACHIEVEMENTS

ELK RIVER (IX-501)

The ELK RIVER was fabricated to serve such naval ocean engineering projects as Man-in-the-Sea, Deep-Submergence Rescue Program, and salvage programs. Originally designed as a Landing Ship Medium Rocket (LSMR 501), the craft was converted to support underwater equipment and test programs. The IX-501 is currently being operated under the cognizance of Submarine Development Group 1 to support the Navy's deep-diving program. One of the newest systems, the Deep-Diving System (DDS) Mk 2, Mod 0, has been installed on the IX-501 and is being used to train divers in the techniques of saturated diving. The Mk 2 system consists of two Deck Decompression Chambers (DDCs) and two Personnel Transfer Capsules (PTCs). Divers are subjected to compression (by either air or helium/oxygen) equal to the depth they will experience in the DDCs. They are then transported with the same internal environment to the ocean depths via the PTC. The Navy has recently completed the deepest recorded ocean dive, 1010 feet, using the Mk 2 system.

SUBMERSIBLE TRAINING PLATFORM

NOSC has recently completed work on a more rugged, larger version of the Launch and Recovery Platform (LARP)—the Submersible Training Platform (SUBTRAP). SUBTRAP is a 24- by 36-foot platform designed to simulate the deck of a slowly moving submarine and is used for Navy diver training operations. During such operations the platform can be towed at selected depths. Maximum depth is 100 feet.

SUBTRAP consists of two parallel, 3.5-foot-diameter, fiber glass pontoons joined by four aluminum cross tubes which support the steel mesh decking, side rails containing additional buoyancy and ballast tanks, and a control console on the forward end of the platform that faces aft and affords the operator an unobstructed view of the platform deck area. To submerge the platform, the main ballast tanks in the fiber glass pontoons are flooded; this submerges the pontoons and deck, while leaving the side rails on the surface. The side rails contain six sealed sectional tanks for permanent buoyancy and four variable-ballast tanks filled with water or air to provide the necessary negative or positive buoyancy. Once the variable-ballast tanks are flooded, the platform is fully submerged. The operator at the control console can now select the depth at which the platform will hover or be towed and keep the platform trimmed by use of the variable-ballast tanks. To ascend, the operator blows the variable-ballast tanks and the main tanks.

Although SUBTRAP's primary function is supporting diver personnel training, its capabilities for lifting (2 tons) and hovering may involve it in salvage and search and recovery tasks.

DIVER'S NAVIGATION SYSTEM

The Diver's Navigation System is an underwater tool designed to aid divers or submersibles in orienting themselves in the ocean environment. The system is composed of two basic subsystems: an acoustic beacon and a receiver. The acoustic beacon functions as the "benchmark" for the diver. The receiver, containing a visual omnidirectional indicator, displays a bearing from the diver to the beacon. The Diver's Navigation System has the capability of selecting one of five beacons, each of a different carrier frequency. These beacons can operate simultaneously. Although in its present form the Diver's Navigation System is basically a locator system, its concept can be extended to a time-navigation system which would use the beacons as reference points to map geographic areas on the ocean bottom. The system has been successfully tested to a range of 550 feet and is designed to operate to depths of 850 feet.

PASSIVE IMAGE-INTENSIFIER GOGGLES

Limited underwater visibility has been a major problem affecting the safety, efficiency, and maneuverability of Navy divers.The limitation of visibility can be due to normally adverse lighting conditions, turbid water, or the restricted use of lighting during covert missions. NOSC has adapted a set of dry-land goggles to demonstrate the feasibility of an underwater viewing device that can enhance the diver's ability to see. The design restrictions of size, weight, power, interfacing, and safety required more development than mere application of state-of-the-art concepts; an advance in the science of optics was necessary.

The intensifier goggles are a self-contained electro-optical device that can be used with a standard diving mask; no bulky power pack or other special equipment is required. The electrical circuits are specially packaged to ensure diver safety. Even when the goggles are not energized, the diver still has adequate peripheral vision through the side lenses of his mask. The goggles are optically corrected for underwater use and work as follows. The optical image is converted to electron image via a photocathode. This image is focused on a microchannel plate intensifier and intensified by an increase in current. Then, via a 5000-volt gradient, the electron image is focused onto a phosphorus screen, where it is reconverted to an optical image. The amplified light makes the image brighter. This bright, clear image enables the diver to accomplish his task under the adverse, limited-visibility conditions noted above.

END

DATE
FILMED
6-81

DTIC